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SURVEY OF OPINIONS AND JUDGEMENTS ON LOAD-CARRYING AMONG SOLDIERS ENGAGED IN COMBAT

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U.S. Army Research, Development and Engineering Command
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14. ABSTRACT
Users who do not have a basic understanding of principles underlying the design of a load system may incur greater strain by not using the features available. The purpose of this survey was to investigate soldiers' understanding of load-carrying. Questionnaires were administered to one hundred fifty-three soldiers engaged in load-carrying in combat. Results show significant differences in load-carrying knowledge among soldiers based on military experience. Those with more experience demonstrate greater understanding of load biomechanics. They better understand trade-offs between good biomechanics and tactical requirements of combat. In contrast, soldiers with less experience are more uncertain about ways to carry loads. The less experienced show a limited understanding of efficient load-carrying techniques. The survey also shows most soldiers do not enter the service with any prior backpacking experience. Results suggest a need to institute realistic load training and instruction on load-carrying early in the soldier's training in order to avoid the costs of having to learn during their first exposure to combat.

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PREFACE AND ACKNOWLEDGMENTS

This report describes efforts by the Ergonomics Team and the Supporting Science and Technology Directorate to collect data on Soldiers' knowledge and understanding of load carrying principles and techniques. The work was funded under the Science and Technology Objective (STO) No. IV.SP.1999.02/Load Carriage Optimization for Enhanced Warfighter Performance of the U.S. Army Research, Development and Engineering Command (RDECOM), Natick Soldier Center from April to May 2003.

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The authors would like to express a special note of appreciation to all the Soldiers who gave their time to completing these questionnaires and offering their valuable comments to the survey questions under very challenging conditions. Without their participation this survey could not have been what it is, viz., a valuable addition to our understanding the soldier's load under operational conditions.

EXECUTIVE SUMMARY

INTRODUCTION

In the design of effective load systems for soldiers, trade-offs should be expected between task requirements and good biomechanical design. For example, distributing the load equally front-to-back may be biomechanically advisable, but, the requirements of infantry in combat do not allow for the placement of substantial loads on the front of the soldier. The foot soldier must have an unobscured view of the ground as he moves over irregular or obstacle-filled terrain. Often the foot soldier is required to hit the ground prone in response to enemy fire. Thus, front loading can impede upon task performance and is impractical for the soldier. Load systems designed for soldiers, therefore, need to account for this and other task-related limitations. In addition, the soldiers' understanding of techniques and fundamental biomechanics of load carrying also needs to be understood and considered. For example, if soldiers believe that it is best to carry the load on their shoulders, they will not utilize "bio-mechanically correct" design features that allow the weight to be equally distributed between the shoulders and the hips. It is, therefore, important to know what soldiers understand and where understanding is deficient about the engineering features of their equipment. In the language of Human Factors Engineering, designers need to know the soldiers' "mental models" of how their equipment works in order to design equipment or implement formal equipment training so soldiers benefit from features with a biomechanical advantage. Load system designers need to understand operational demands and soldier understanding of load carriage in order to determine what features, however innovative, may or may not work for the soldier. The main objective of this survey was to gain some understanding of the operational demands of load carrying during combat in particular and the soldiers' knowledge and understanding of load carriage in general.

METHOD

The questionnaire used in this survey was designed to elicit soldiers preferences and knowledge of load carrying techniques relative to their requirements for infantry combat operations. It was divided into three sections: I: Background and Prior Experience, II: Structured Questions on Load Carrying, and III: Open-ended questions on load carrying. One hundred fifty three soldiers completed the surveys between combat actions in their base camp.

RESULTS AND DISCUSSION

The soldiers who responded to this survey are highly representative of infantry units in the Army in general, in terms of their Military Occupational Specialties (MOS) and background demographics. Knowledge gained from this survey of soldiers' preferences and understanding of load carrying may

reasonably be projected as the preferences and understanding of the general infantry soldier in the US Army at the time of the survey.

To assess the influence of experience on judgments about load carriage, soldiers were divided into three subgroups according to years of military experience: 0-3 years, 4-7 years, and more than 7 years. The groupings represent relevant blocks of experience as those with 0 to 3 years would be expected to have limited experience in carrying combat loads while those with more than 7 years would be expected to have a great deal of experience.

Results show soldiers with less experience had few if any preferences for the type of load system they used. Similarly, they were not as likely to report preferences for types of footwear or for ways of securing straps, pouches, and other items in and on the rucksack. Apparently, those with less experience are less likely to have developed any preferences due to the lack of opportunity to experiment with load equipment and learn effective load carrying techniques.

Likewise, those with less experience appear to have limited intuitive understanding of the biomechanics of load carrying. Soldiers with less experience were more likely to suggest that heavy weight should hang off the back of the ruck. They were the only subgroup that did not suggest putting heavy items on the top of the ruck.

The less experienced soldiers were more likely to agree with the statement that weight should be distributed evenly top to bottom. Soldiers with less experience were uncertain about the placement of heavy items within the ruck, namely, whether items should be kept close together or spread apart. Additionally, soldiers with less experience were more likely to indicate that it does not matter how a piece of equipment is used or how the load is carried, and to not to prefer any given option. They were more likely to consider the question of how the load is carried up or down hills to be unimportant.

Results further suggest that less experienced soldiers were not as likely to feel they have much control in making the load comfortable. Without skill in load arrangement, they may not understand how to lessen discomfort and view the situation as if no improvements can be made. Less accustomed to the demands of load carrying, these soldiers may be attending more to aches and pains. Indeed, these soldiers were more likely to report moderate-to-great mid back discomfort. They were more likely to indicate great-to-extreme head lean as well as great-to-extreme tendency to be bent over after prolonged marching. This, as mentioned above, may be related to the reported inclination of these soldiers to hang items off the back of the ruck. Ultimately, soldiers with less experience may feel they have less control because they are unable to affect a change to their discomfort with loads. However, soldiers may also be faced with the fact that their leaders often dictate what equipment they carry and how it is carried.

In contrast to the soldiers with less experience, those with more experience were more likely to report a load system preference. These soldiers felt more strongly about keeping heavy items together inside the ruck. They were the only subgroup of infantrymen to advise carrying the weight on the hips as well as the shoulders, which may be advisable.

The more experienced soldiers preferred slowing their movement while traveling through soft ground. Traveling over soft or loose ground increases physical effort and fatigue. It is, therefore, inadvisable to require soldiers to maintain the same rate of movement while on soft ground. As the evidence shows, slowing over difficult terrain conserves energy and may prevent injury. However, slowing may be tactically dangerous in open terrain, forcing the combat soldier to move as rapidly as possible.

Familiar with the demands of actual combat, soldiers with more experience tend to emphasize the greater importance of realistic load training. Those with more military combat experience understand the importance of being fully trained and prepared for the physical as well as mental challenges of engagement with the enemy. Realistic combat training allows soldiers to become accustomed to their equipment and familiar with standard operating procedures. Furthermore, in theory, highly trained and conditioned soldiers have a lower cognitive load. This allows soldiers to pay more attention to critical details of combat and to be less distracted by the dynamics of load carrying.

Although soldiers with different levels of experience varied in general knowledge about load carriage, they did not differ in their responses to a few specific items. Across all levels of experience, the ALICE pack was preferred. Previous research suggests that soldiers find the ALICE pack to be well balanced, stable on the body, and easy to adjust. In general, short, wide rucks were favored over long, narrow rucks.

Another area of agreement among soldiers to this survey is in the distribution of load. Most advised distributing the load evenly left and right as well as front and back, which is relatively intuitive even for those with little experience. In contrast, they also recommended keeping the load off the hands and the feet, which is not relatively intuitive. This may reflect knowledge of the added energy cost of carrying weight in the hands and on the feet, or awareness of operational demands. Physiological research supports the load carriage recommendations given by the soldiers.

Most soldiers agreed that items should be tightly attached to the ruck. In their comments, they advised that items be securely attached to prevent shifting or loss of equipment. Most also thought the weight should be carried primarily on the shoulders. However, as previously mentioned, research suggests that carrying the load primarily on the shoulders is not recommended.

In contrast to the strongly reported preference to carry the weight primarily on the shoulders, respondents showed no preference as to whether the load should be maintained in one position or varied throughout a prolonged march. It is unclear whether respondents fully understood the phrasing of the question: "Do you prefer to shift the weight of the rucksack around during the march or maintain the load in the same position throughout?" If soldiers thought "maintaining the same position" meant that the configuration within the ruck should remain the same, responses would be different than if the question meant that the load should not be shifted on the shoulders during a march. If all the soldiers understood the question to be whether they should shift the load on their torso in order to avoid fatiguing certain muscles, then there might have been more agreement favoring changing the load position.

Although no decisive preference is indicated about shifting the load, regardless of experience level, soldiers claimed to spend a great deal of time making the load comfortable. It was not specified whether this refers to the time spent arranging equipment within the ruck before marching begins, or adjustments made throughout the march by adjusting the placement of the ruck on the back. Despite significant time reported for making the load comfortable, soldiers described great-to-extreme shoulder discomfort. Shoulder discomfort may be inevitable due to the stress of prolonged marching with heavy loads.

Across all levels of experience, soldiers agreed in regards to footwear. They preferred tightly tied boots, to prevent blistering from the foot slipping in the boot. Similarly, they valued well-broken-in footwear and favored lighter verses heavier boots. Made of lighter material, lighter boots cause less leg fatigue. After extended marching, they allow heat and sweat to more easily escape. These boots tend to be more flexible, mold better to the foot, and offer adequate support.

Most soldiers indicated that discomfort from heavy loads does not significantly and adversely affect mental concentration. The experimental research on this, however, is equivocal.

Finally, it should be noted that most soldiers reported no civilian backpacking experience prior to entering the military. The lack of prior experience suggests that knowledge about load carrying is obtained primarily through field exercises or in actual combat. The Army does not routinely offer special instruction or training in load carrying. The results of this survey suggest that those with more experience have acquired an intuitive knowledge about the biomechanics of load carrying as well as knowledge of the trade-offs between good biomechanics and the requirements of tactical combat.

SURVEY OF OPINIONS AND JUDGEMENTS ON LOAD-CARRYING AMONG SOLDIERS ENGAGED IN COMBAT

INTRODUCTION

In March 2002, Coalition Forces operating in Afghanistan attacked large-scale Anti-Coalition Militant (ACM) concentrations located in the Shah-Ei-Kowt region of Afghanistan. Operation Anaconda was the first major mountainous winter operation conducted by the U.S. Army and its coalition partners since the Italian Campaign in World War II. After the commencement of the Anaconda fight, it was suggested that the U.S. Army conduct a combat study of modern loads carried by the dismounted forces in Afghanistan. The results of such a study would not only assist the Army's material developers in designing improved, lightweight, mission essential equipment, but also enhance the distribution of knowledge obtained from the units fighting in the rugged Afghan climates and terrains. As the idea of such a study gelled, the Commanding General of the U.S. Army's Soldier and Biological Chemical Command (SBCCOM) requested that the U.S. Army's Center for Army Lessons Learned (CALL) execute a soldier load study in Afghanistan. The capturing of modern day combat load data was critical to SBCCOM for its research and to the Program Executive Office Soldier's (PEO Soldier) in its final development and fielding of enhanced, lightweight equipment for the Army's Future Force. In addition, the Chief of Staff of the U.S. Army stated in 2001 that the combat load of the individual soldier serving in the Future Force was not to exceed 50 pounds. SBCCOM and PEO Soldier recognized that in order to achieve this significant weight reduction by the introduction of the Future Force in 2010, baseline data on current loads needs to be compiled. The most accurate place to collect such data would be in combat.

The CALL at Fort Leavenworth, KA accepted the mission for recording this critical data and asked SBCCOM's Natick Soldier Center to provide the team leader for the effort. The team leader immediately went to work to build a team of experienced soldiers. Knowing that these men would be expected to face the same dangers and carry the same combat loads as the Infantrymen they would be studying in Afghanistan, the team leader chose a team composed of volunteer Infantrymen with extensive light Infantry experience that was both airborne and ranger qualified. The resulting team came from PEO Soldier, SBCCOM, and the Infantry School and Center, with half of the men having served in previous combat operations and all having held leadership positions within light Infantry units. The team leader and the team sergeant led the team through combat refresher training at both Fort Bragg, NC and Fort Benning, GA prior to deploying the team through the CONUS Replacement Center at Fort Benning and then into Afghanistan at the end of March 2003. On 2 April 2003, the CALL's Soldier Load Combined Arms Assessment Team (CAAT) was formally attached to Task Force Devil, Coalition Task Force 82, Kandahar, Afghanistan. The team re-designated itself the "Devil CAAT" in honor of the elite parachute regiment in which they

were now serving. In the early morning hours of 8 April 2003, four members of the Devil CAAT participated in the team's first major combat mission, air assaulting with a battalion task force into Sangin, Afghanistan. By the time all data were collected in May 2003, the team participated in 15 separate combat actions as members of the 82nd Airborne Division. This report is only part of that effort, namely, to survey the opinions on methods of load carrying. Other aspects of the main effort are reported elsewhere.

BACKGROUND ON THE LOAD SURVEY QUESTIONNAIRE

The complex task of designing effective load systems requires understanding the needs and requirements relative to the tasks soldiers perform, as well as the soldiers' knowledge and application of biomechanical principles. In the design of effective load systems for soldiers, trade-offs should be expected between task requirements and good biomechanical design. For example, distributing the load equally front-to-back may be bio-mechanically advisable, however, the requirements of infantry in combat do not allow for the placement of substantial loads on the front of the soldier. The foot soldier must have a clear view of the ground as he moves over irregular or obstacle filled terrain. Often the foot soldier is required to hit the ground prone in response to enemy fire. Thus, front loading can impede upon task performance and is for the most part impractical for the soldier. Load systems designed for soldiers need to account for this and other task related limitations.

Knowledge of soldiers' understanding about the techniques and fundamental biomechanics of load carrying is equally important for the design of effective load systems. For instance, if soldiers believe that it is best to carry the load on their shoulders, they will not utilize "bio-mechanically correct" design features that allow the weight to be equally distributed between the shoulders and the hips. It is, therefore, important to know what soldiers understand and where understanding is deficient about the engineering features of their equipment. In the language of Human Factors Engineering, we need to know the soldiers' "mental models" of how their equipment works in order to design equipment or implement formal equipment training so soldiers benefit from features with a biomechanical advantage. We also need to increase knowledge of the operational demands of the soldier in order to determine what features of a newly engineered system, however innovative, may never aid the soldier. The main objective of this survey was to augment understanding of user task requirements and soldiers' knowledge about load carriage.

METHOD

The questionnaire used in this survey was designed to determine soldiers preferences and understanding of load carrying relative to their requirements for executing infantry combat actions. Questions were derived from a series of original statements about the biomechanics and comfort of load carrying during military movements. These statements were revised with the help of several biomechanics researchers at the Natick Soldier Center and put in questionnaire fixed choice formats. Additional, open-ended questions were added in order to address some of the same issues, but to allow more freedom for the respondents to explain their answers to the questions. Thus, the questionnaire is divided into three sections: Section I: Background and Prior Experience, Section II: Structured Questions on Load Carrying, and Section III: Open ended questions on load carrying. A copy of the questionnaire is presented in the Appendix.

The surveys were printed and prepared by the Ergonomics Team at the US Army Natick Soldier Center for distribution in the field. They were distributed in April and May of 2003 by the second and third authors who made contact with the 2nd and 3rd Battalions of the 504th Parachute Infantry Regiment. The units completed the surveys between combat actions in their base camp at Kandahar International Airport, Afghanistan. One hundred fifty three questionnaires were fully completed and the results are presented below.

RESULTS

BACKGROUND PROFILES OF RESPONDENTS

The majority of the respondents (Figure 1) were in the Military Occupational Specialty (MOS) 11B, Infantryman, (139 respondents). Four respondents were Infantry Officers (11A), and five respondents were Medics (91W).

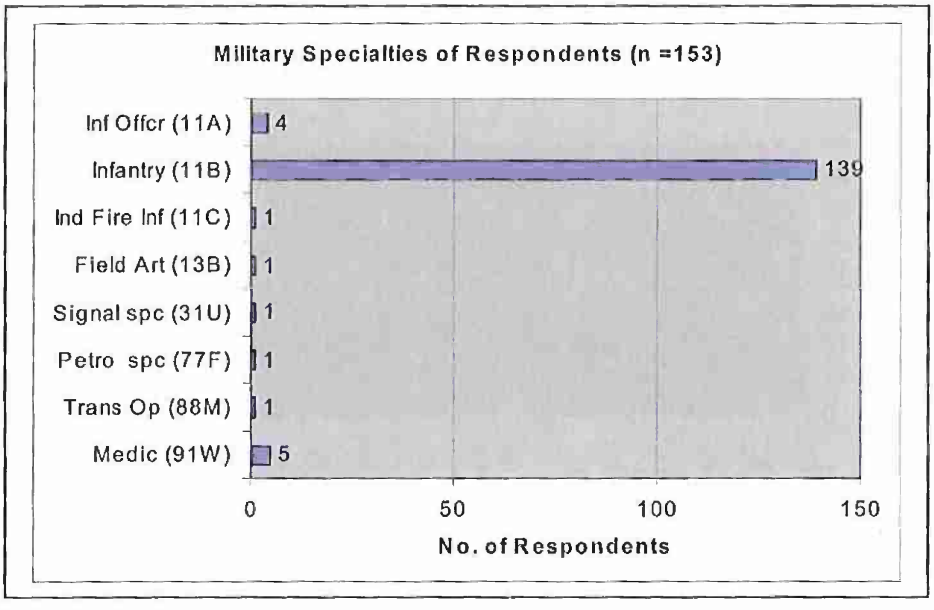

Figure 1. Military Specialties of Respondents.

For analysis of experience, respondents were divided into subgroups by years experience in the military as depicted in Figure 2. In this sample, 35 respondents had over 7 years in the military, 53 had from 4 to 7 years and 65 had 3 or fewer years. The average age for each group was 30.3, 23.9, and 20.6 years, respectively.

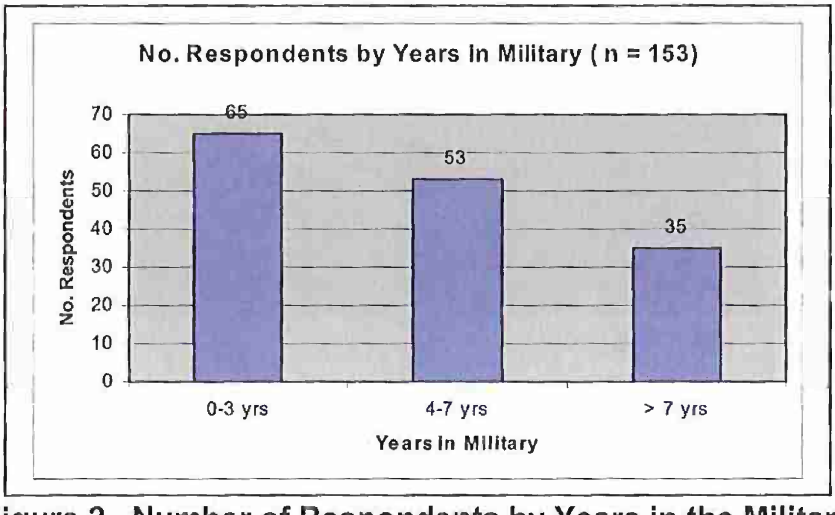

Figure 2. Number of Respondents by Years in the Military.

Figure 3 shows the body weight profile of respondents (in pounds) and Figure 4 shows the height profile of respondents (in inches). Approximately ninety percent of total respondents weighed between 146 and 196 pounds. Height ranged from 51-80 inches, with 97 percent of respondents ranging between 62-76 inches.

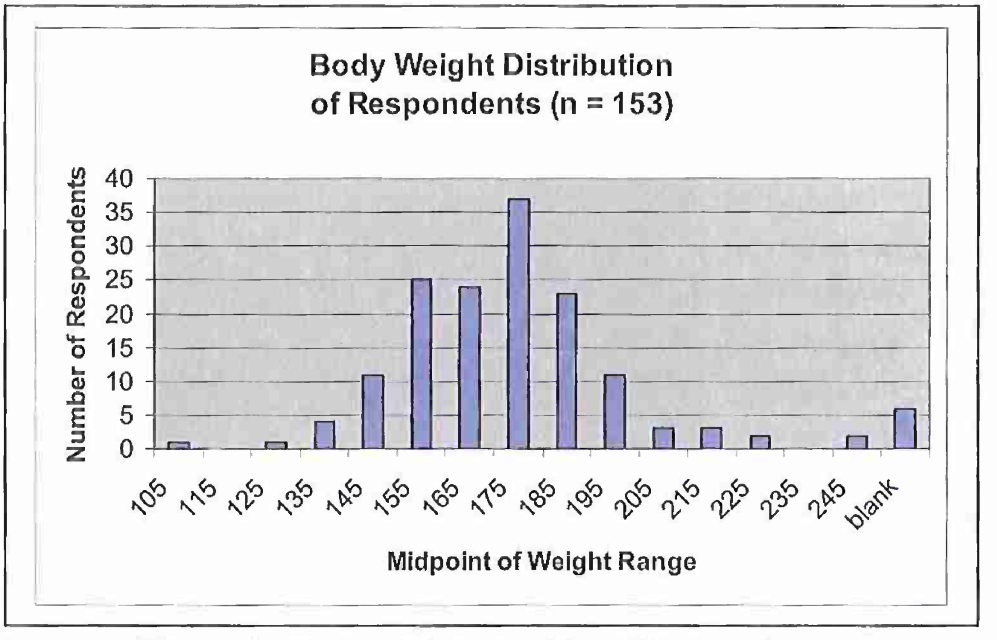

Figure 3. Body Weight Profile of Respondents.

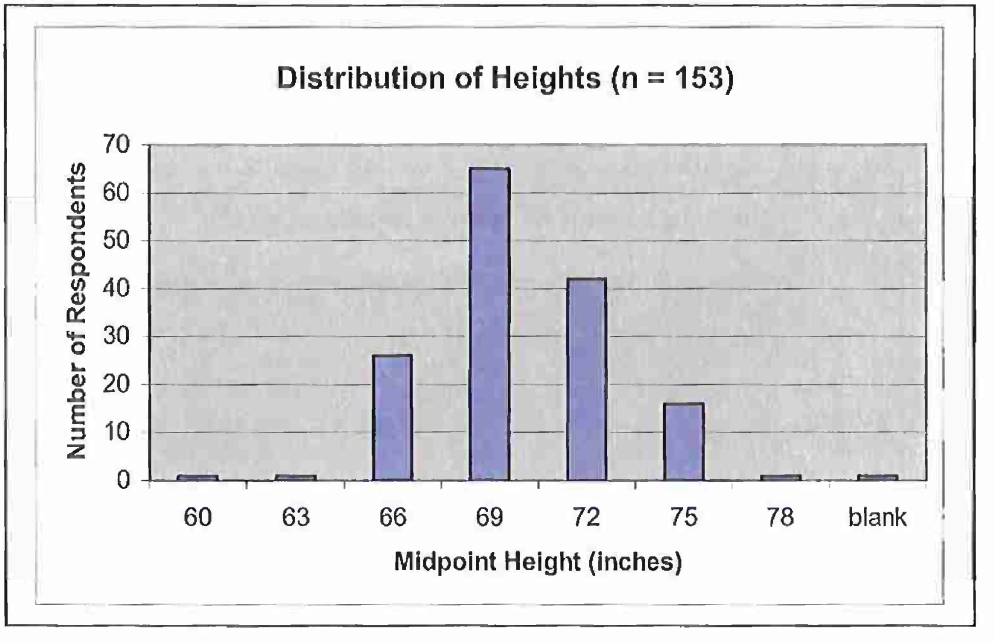

Figure 4. Height Profile of Respondents.

Figure 5 shows that most respondents (70.6 percent of total) reported no civilian backpacking experience prior to entering the military. This trend is consistent across all three subgroups of military experience, with only 28.1 percent of the total respondents reporting civilian backpacking experience.

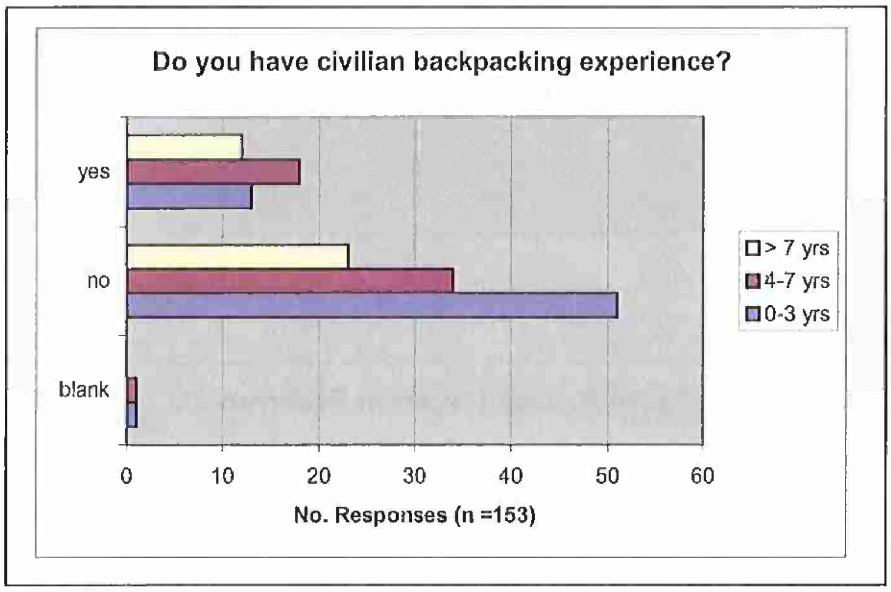

Figure 5. Civilian Backpacking Experience.

STRUCTURED QUESTIONS

Figure 6 suggests that these respondents foster a preference for a particular load system. Approximately 50.3 percent of total respondents indicated a load system preference, while forty-six percent of total respondents reported no preferred load system. Respondents with less military experience tended to report no preference for type of load system. In contrast, those with more military experience tended to report a load system preference. Of respondents with 0-3 years of military experience, 66.2 percent indicated no preference, while 68.6 percent of respondents with 7 or more years of military experience reported having a preference.

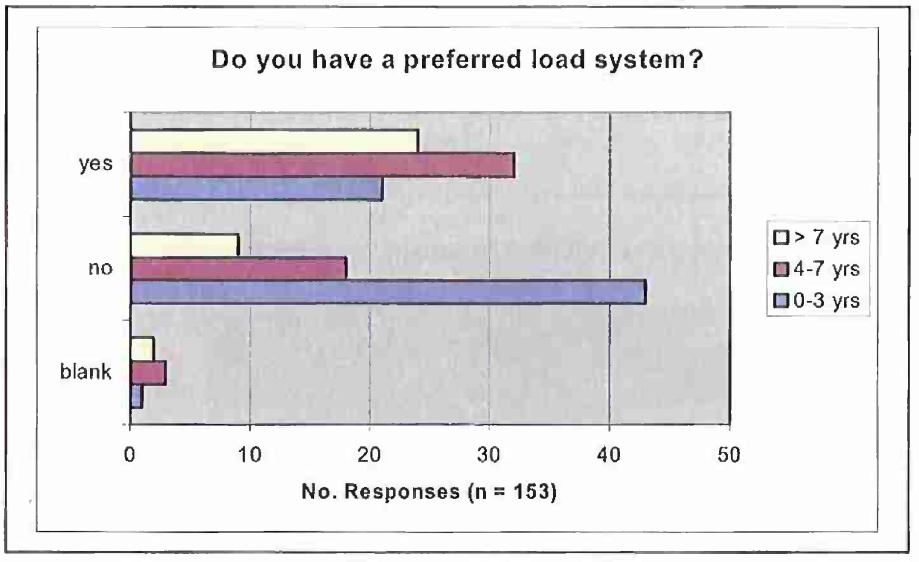

Figure 6. Load System Preference.

Figure 7 and statistical analysis suggest that the legacy ALICE (All-purpose Load Individual Carrying Equipment) system is significantly preferred over the new MOLLE (Modular Lightweight Load-carrying Equipment) system and internal frame systems ($P < 0.01$).

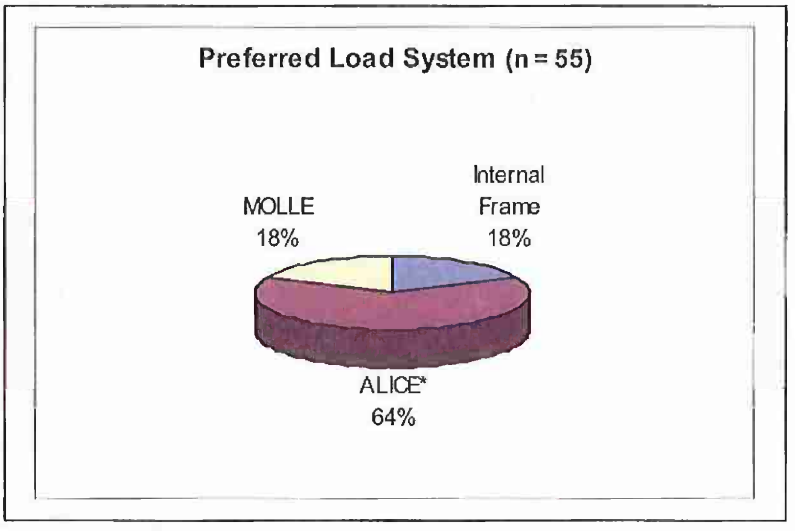

Figure 7. Preferred Load System.

Table 1 presents comparisons of load system preferences by years experience in the military. Results of a critical difference between proportions test (Glass & Stanley, 1970, p. 326) indicate that the ALICE system is preferred by each group ($p<.01$). Sixty-four percent of all respondents designated the ALICE system as the preferred load system, whereas 18 percent designated the internal frame system and 18 percent designated the MOLLE system as the preferred load system (Table 1).

Table 1. Load System Preferences by Years in the Military.

Prefer	Totals	0-3 yrs	4- 7yrs	> 7 yrs	percent
Internal Frame	**10**	2	4	4	**18%**
ALICE*	**35**	18	5	12	**64%**
MOLLE	**10**	7	1	2	**18%**
Totals	**55**	27	10	18	**100%**

Figure 8 shows recommendations for load distribution front and back. Across all experience groups, approximately sixty-seven percent of all respondents agreed that loads should be distributed equally front to back.

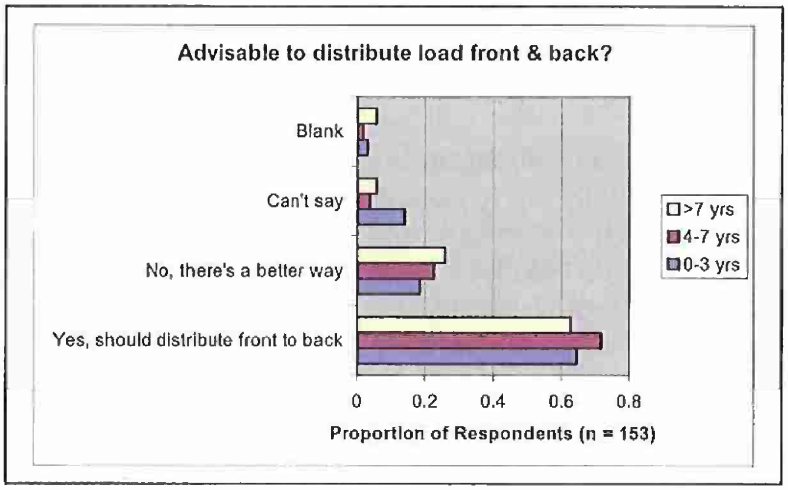

Figure 8. Load Distribution Front and Back.

Responses about load distribution left and right are shown in Figure 9. Eighty-four percent of respondents agreed that the load should be distributed equally left to right. All respondents with 4-7 years military experience answered the question conclusively, while 9.2 percent of respondents with 0-3 years military experience and 11.4 percent of respondents with more than 7 years military experience reported uncertainty.

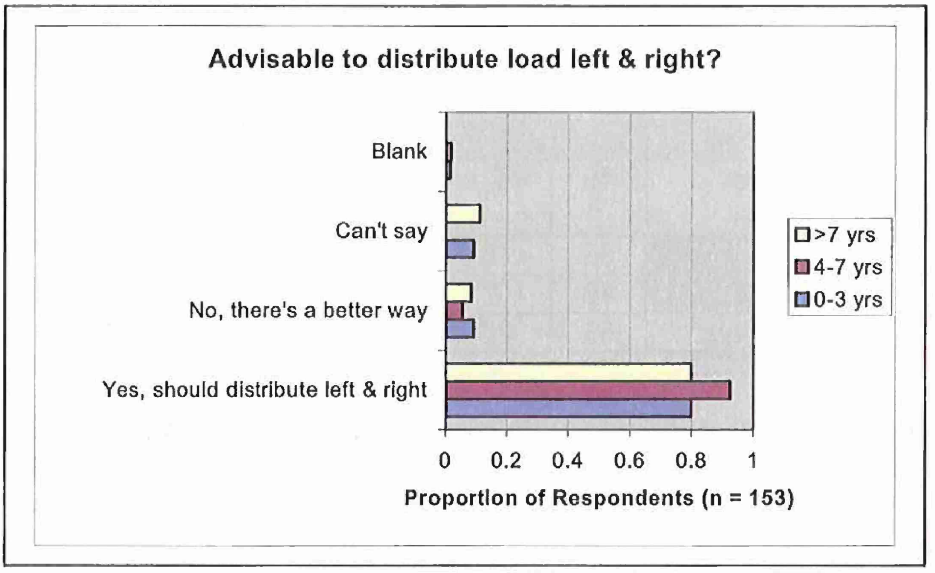

Figure 9. Load Distribution Left and Right.

Less agreement was evident among respondents as to whether the load should be distributed equally top to bottom (Figure 10). Respondents with more military experience tended to think there are more advisable ways of distributing the load, while respondents with less experience agreed distributing the load equally top to bottom is best. Approximately fifty-one percent of respondents with more than 7 years military experience indicated that there is a better way to distribute the load, in comparison to 35.9 percent of respondents with 4-7 years military experience and 27.7 percent of respondents with 0-3 years of military experience.

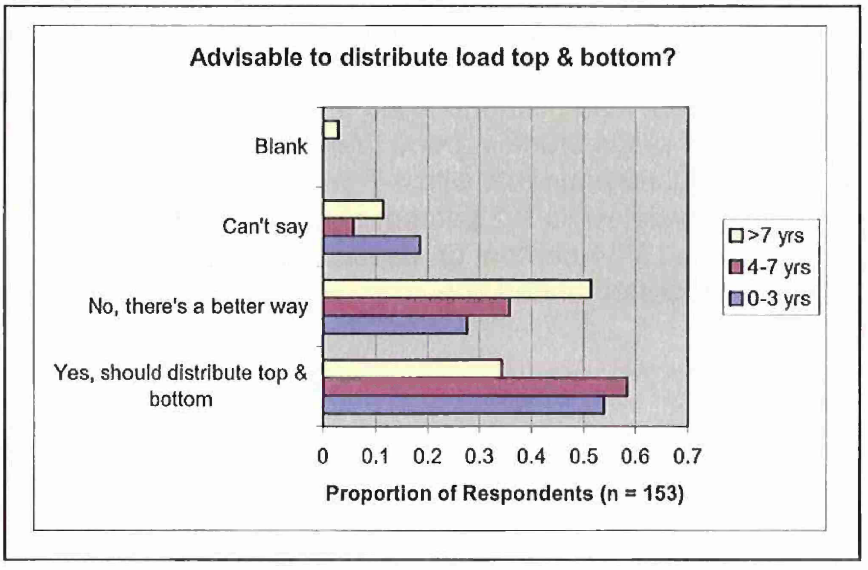

Figure 10. Load Distribution Top and Bottom.

Figure 11 addresses the method of carrying large, heavy items. Fifty-eight percent of all respondents indicated that it is best to carry large, heavy items inside the ruck and near the frame. Interestingly, 32.3 percent of respondents with 0-3 years military experience indicated that heavy weight should hang off the back of the ruck, farthest from the body. Only respondents from this experience subgroup advised this method of carrying heavy items. Similarly, only respondents with 0-3 years military experience did not recommend carrying heavy items on the top of the ruck. Twenty-two percent of respondents with 4-7 years military experience and nearly 26 percent of respondents with more than 7 years military experience suggested that heavy items should be placed on top of the ruck.

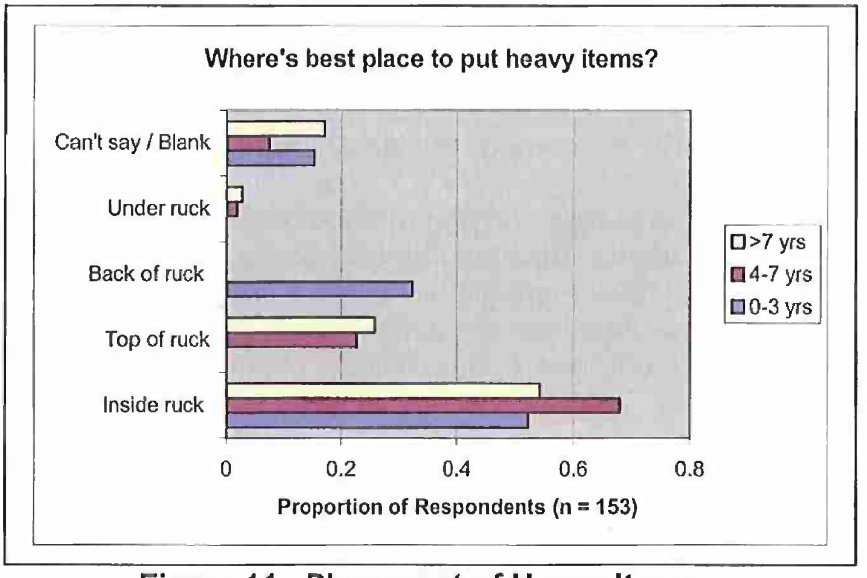

Figure 11. Placement of Heavy Items.

The majority of all respondents indicated that heavy items should be kept together inside the ruck (mean = 55.6). Respondents with more than 7 years military experience most strongly supported this method of carrying load, with 71.4 percent in favor of keeping items together. Only 5.7 percent of respondents with more than 7 years experience reported no recommendation, while 30.8 percent of respondents with 0-3 years and 22.6 percent of respondents with 4-7 years experience indicated uncertainty. See Figure 12.

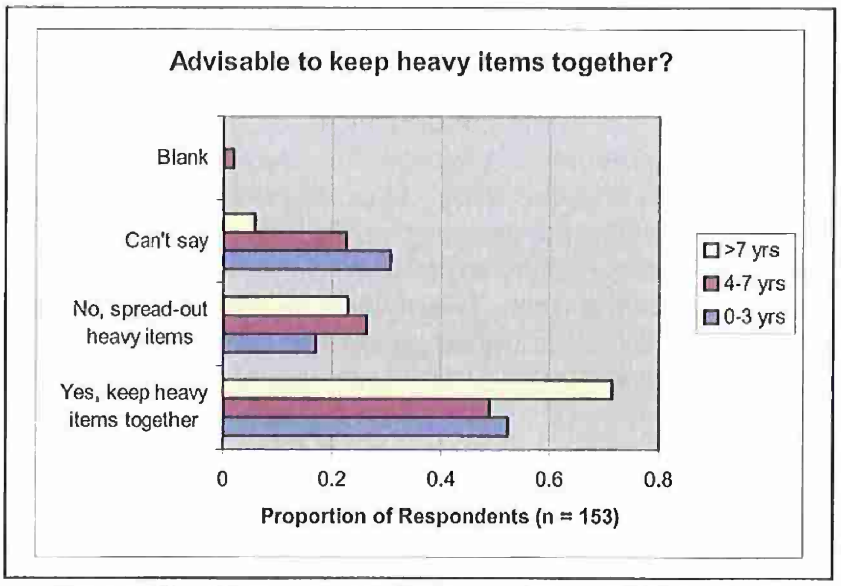

Figure 12. Placement of Heavy Items Within Ruck.

Figure 13 illustrates ruck carrying method preference. Seventy-three percent of total respondents indicated that they prefer to carry the weight of the ruck on the shoulders. Most respondents with 4-7 years military experience suggested that the shoulders bear the weight of the load (88.7 percent). Only a few respondents with more than 7 years military experience advised carrying weight on hips.

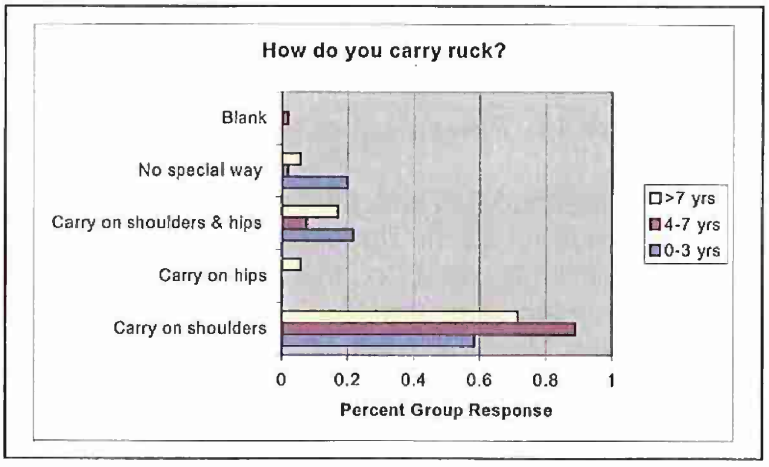

Figure 13. Preferred Way to Carry Ruck.

Preference on how to secure attachments (loose or tight) is shown in Figure 14. Approximately eighty-seven percent of all respondents favored keeping straps, pouches, and items tightly attached. Respondents with 4-7 years military experience either favored keeping things loose (5.7 percent) or keeping things tight (94.3 percent). In contrast, 10.8 percent of respondents with 0-3 years military experience indicated no preference at all.

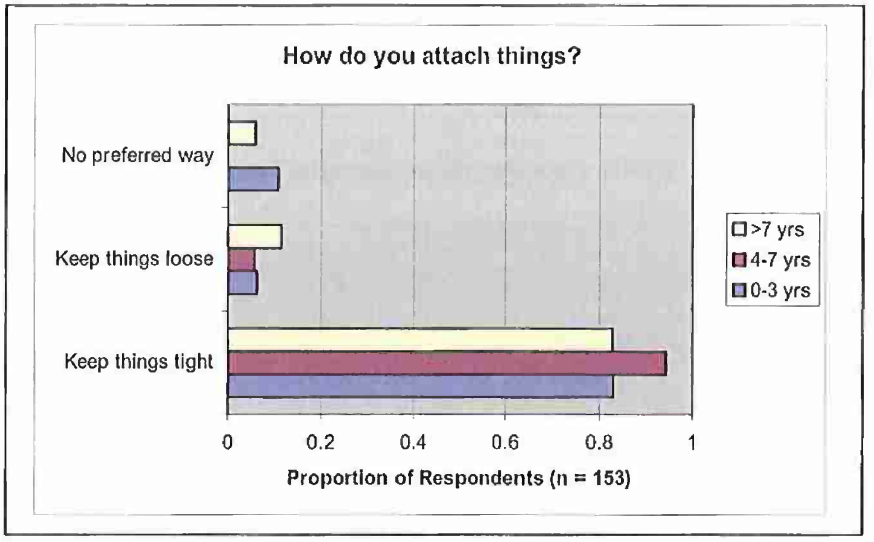

Figure 14. Tight or Loose Attachment.

There tended to be little agreement about whether the load should be maintained in one location on the back or varied during movement (Figure 15). Fifty-four percent of total respondents favored a fixed position, while 41.2 percent of total respondents favored varying load arrangement. (This was also asked in question 26 and the results shown in Figure 27 are similar. Respondents with more experience preferred the fixed position.)

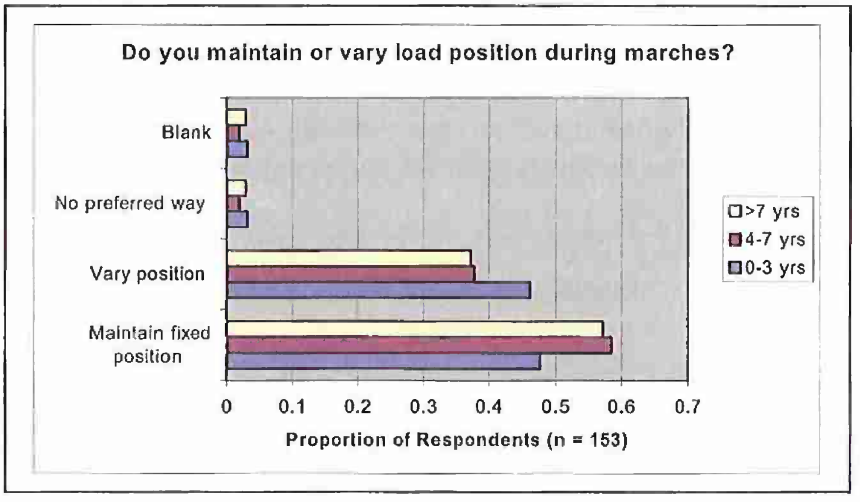

Figure 15. Load Maintenance or Variation During March.

Figure 16 shows how the soldiers prefer to carry loads when marching up hill. Sixty-one percent of total respondents recommended carrying the load high, 17.7 percent of total respondents recommended centering the load, and 8.5 percent of total respondents recommended the load to be low. Unsurprisingly, 18.5 percent of respondents with 0-3 years military experience indicated that it does not matter while few experienced soldiers were likely to remain neutral. Only 1.9 percent of respondents with 4-7 years military experience and 8.6

percent of respondents with more than 7 years military experience reported no preference.

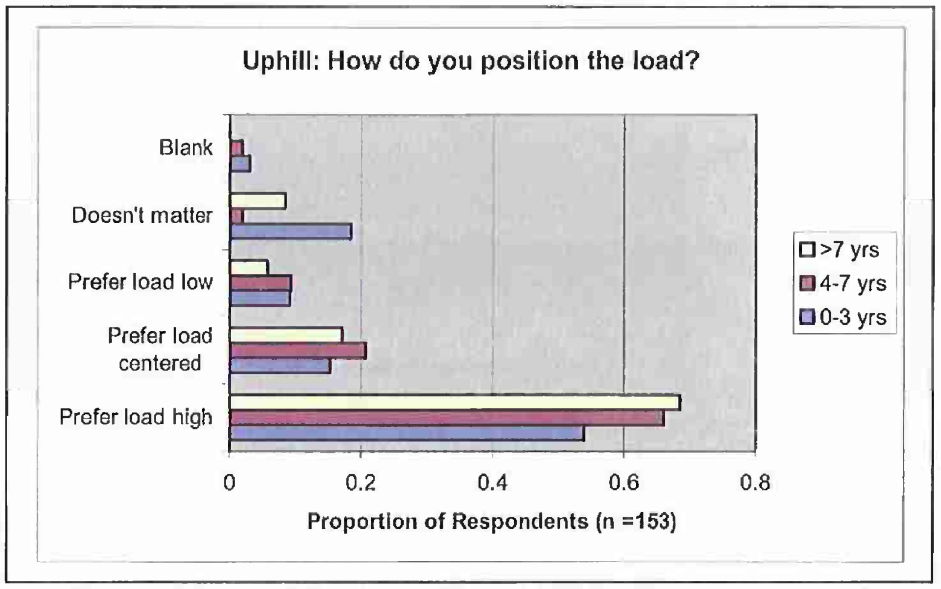

Figure 16. Positioning of Load While Marching Uphill.

There was less agreement about where to place the load for down hill (Figure 17). Thirty-six percent of total respondents indicated a preference for carrying the load high, 34 percent of total respondents indicated a preference for centering the load, and 13.7 percent of total respondents preferred the load to be low. Respondents with more than 7 years military experience recommended carrying the load high when traveling down hill (51.4 percent), but respondents with 4-7 years military experience favored centering the load (43.4 percent).

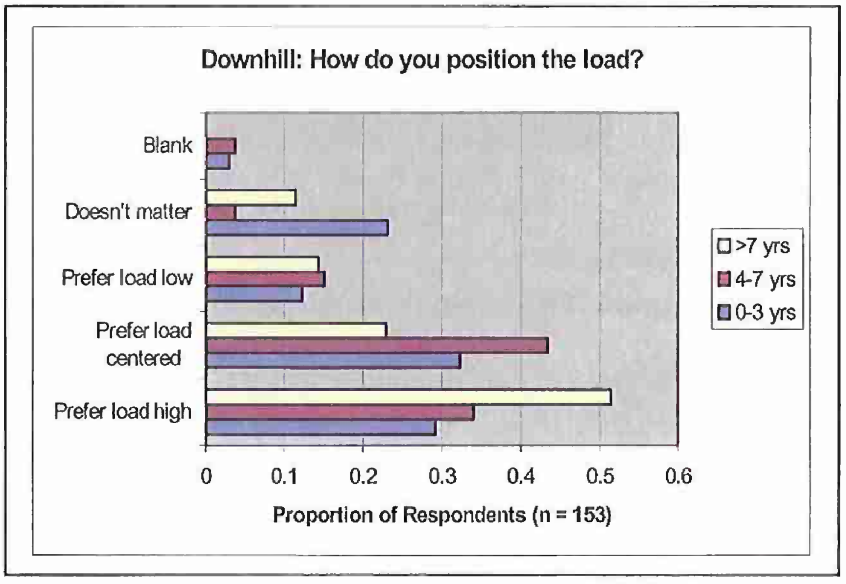

Figure 17. Positioning of Load While Marching Downhill.

Preference for shape of load system is illustrated in Figure 18. Fifty percent of total respondents preferred short wide packs while 24.8 percent of total respondents preferred long narrow ones. This corresponds to the previously mentioned preference for the ALICE pack.

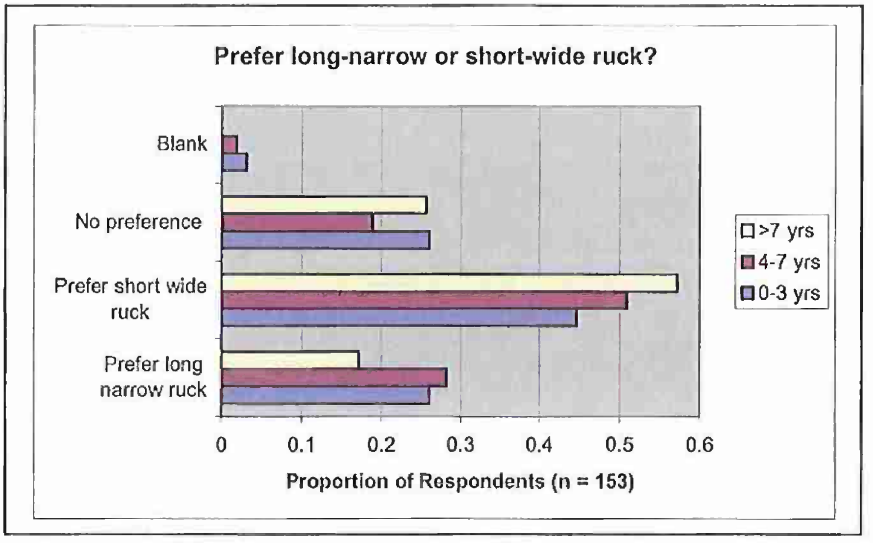

Figure 18. Preference for Long-Narrow or Short-Wide Ruck.

When asked about movement over soft ground with heavy loads, most indicated a tendency to slow down (Figure 19). Sixty percent of respondents with more than 7 years of military experience would prefer slowing movement. However, not all respondents favored slowing pace. Approximately thirty-one percent of total respondents indicated that they attempt to maintain the same rate as on harder ground, and 5.2 percent of total respondents even indicated that they would prefer to move more quickly. Fifteen percent of total respondents reported no preference for moving over difficult ground.

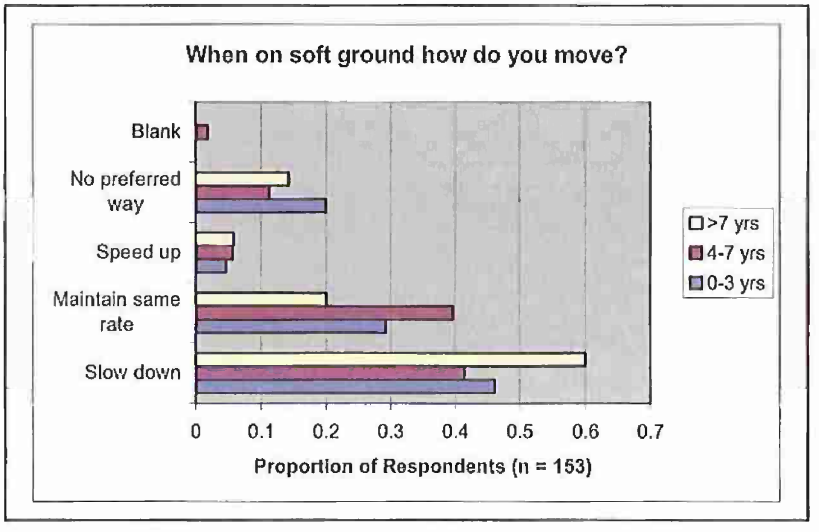

Figure 19. Movement on Difficult Ground.

Eighty-one percent of all respondents indicated that they prefer to tightly tie their boots when carrying heavy loads (Figure 20).

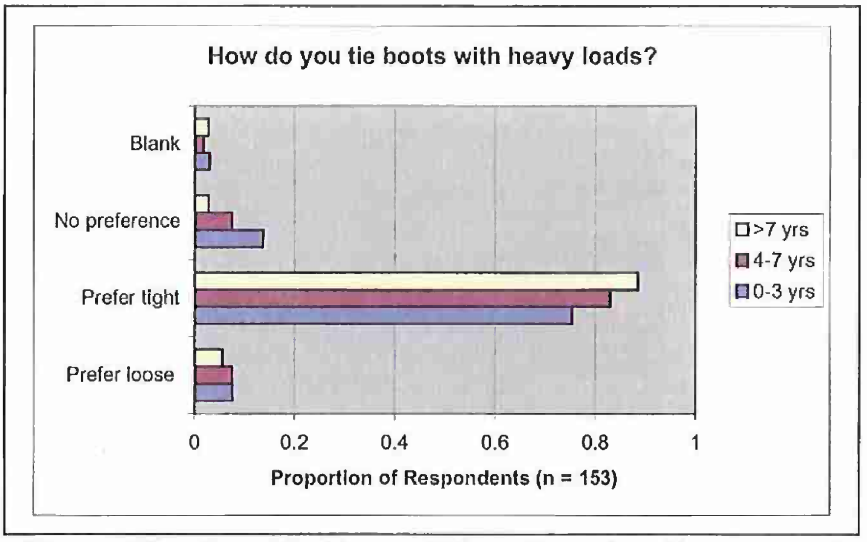

Figure 20. Boot Tightness When Carrying Heavy Loads.

Similarly, respondents preferred lighter, verses heavier, boots with heavy loads (Figure 21). Seventy-nine percent of total respondents preferred heavy footwear, while a mere 5.2 percent of total respondents favored heavy footwear. Sixteen percent of total respondents had no preference, with 23.08 percent of respondents with 0-3 years military experience indicated no footwear inclination.

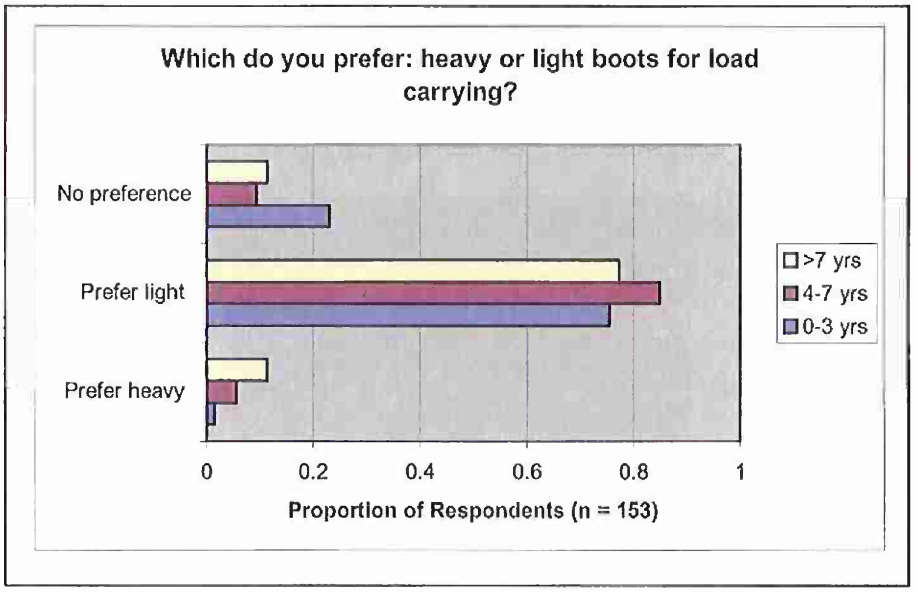

Figure 21. Boot Type (Heavy or Light) for Load Carrying.

Figure 22 illustrates movement preference uphill. When approaching a hill, 56.2 percent of total respondents indicated that they would prefer to zig-zag up the hill. Respondents with 4-7 years military experience responded most affirmatively that they would prefer to go straight over the hill (39.62 percent). Surprisingly similar to those with only 0-3 years military experience, 17.14 percent of respondents with more than 7 years military experience reported no preference for movement pattern.

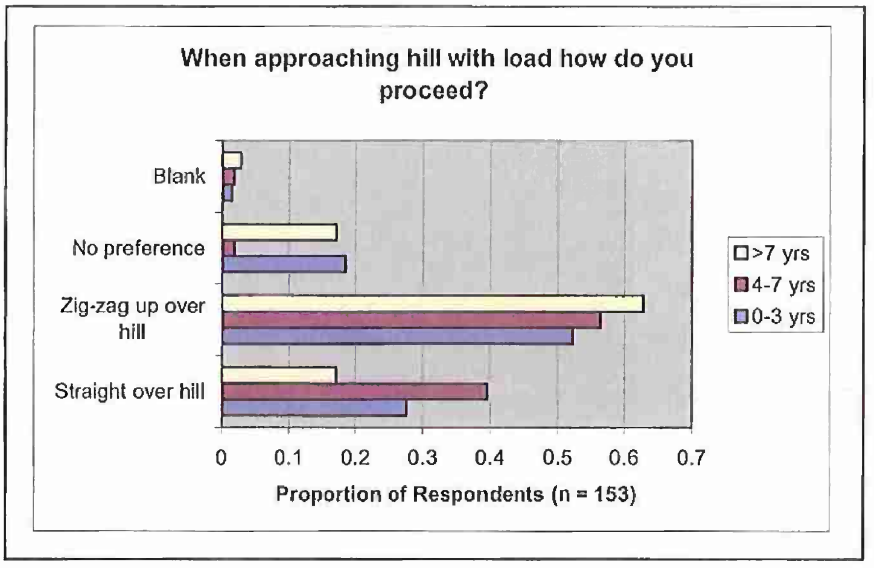

Figure 22. Movement Uphill While Carrying Load.

Boot condition is addressed in Figure 23. Seventy-seven percent of respondents with 0-3 years military experience, 96.2 percent of respondents with 4-7 years military experience, and 94.3 percent of respondents with more than 7 years military experience agreed that it is extremely important to have well-broken-in footwear for prolonged marches.

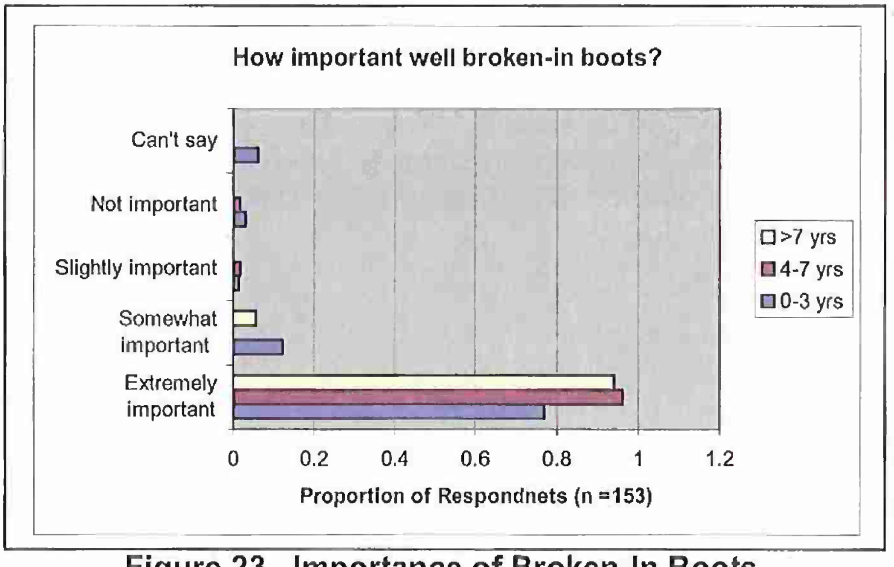

Figure 23. Importance of Broken-In Boots.

Respondents generally agreed that weight should be kept off the hands and feet (Figure 24). Forty-eight percent of total respondents expressed that it is extremely important to reduce the load for the hands and feet, and 37.9 percent of total respondents indicated that it is somewhat important to reduce the load for the hands and feet.

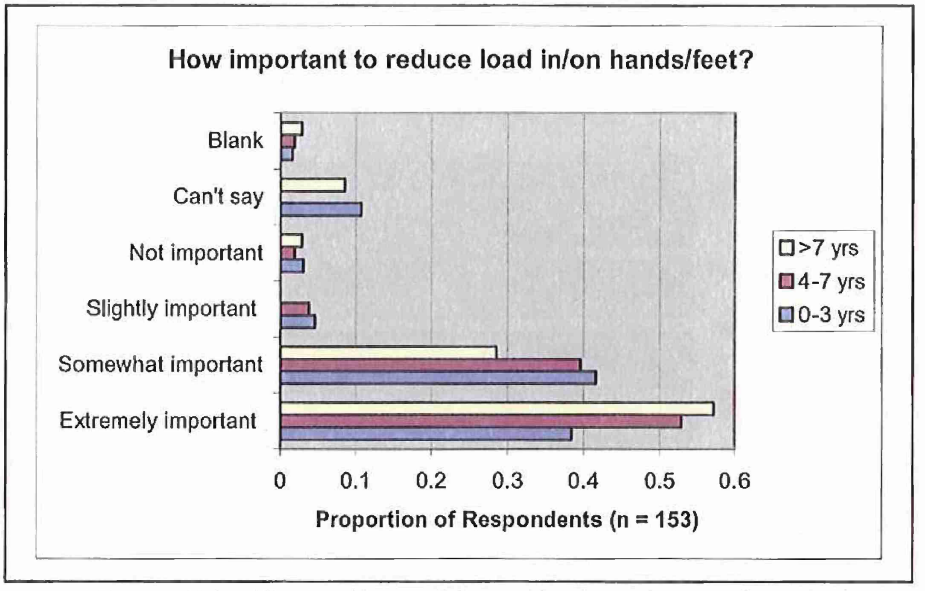

Figure 24. Reduction of Load in Hands and/or Feet.

With results resembling those of Figure 15, Figure 25 displays a slight preference among more experienced respondents for maintaining a fixed position of the load during movement. The wording of the two questions differs slightly, as the responses shown in Figure 15 address the question "do you maintain or vary load position during marches?" and the responses shown in Figure 25 address the question "how do you like to carry load?" For the later question, respondents with 0-3 years military experience indicated more preference for shifting the load during prolonged movement on this version of the question (56.9 percent) than on the previous version (46.2 percent). Respondents with more than 7 years military experience who previously encouraged a fixed position still recommended a fixed position (51.4 percent) over shifting positions (40.0 percent).

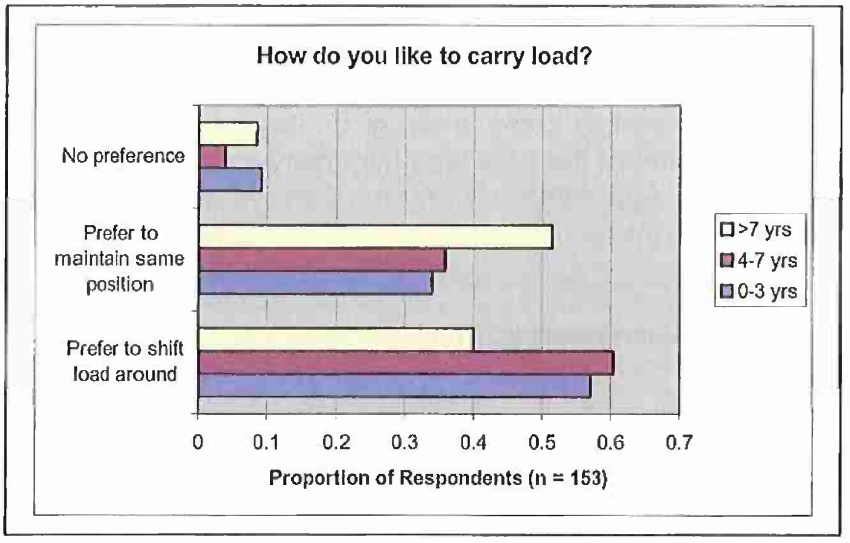

Figure 25. Load Carrying Preference.

The importance of training with full combat loads is shown in Figure 26. Eighty-six percent of respondents with more than 7 years military experience considered it extremely important to train with the same weights and types of loads to be expected in combat. Among respondents with 0-3 and 4-7 years military experience, less importance was placed upon realistic load training. Seventy-four percent of respondents with 4-7 years military experience and 50.8 percent of respondents with more than 7 years military experience regarded realistic training as extremely important. Respondents with less experience were more likely to say realistic load training is only somewhat important.

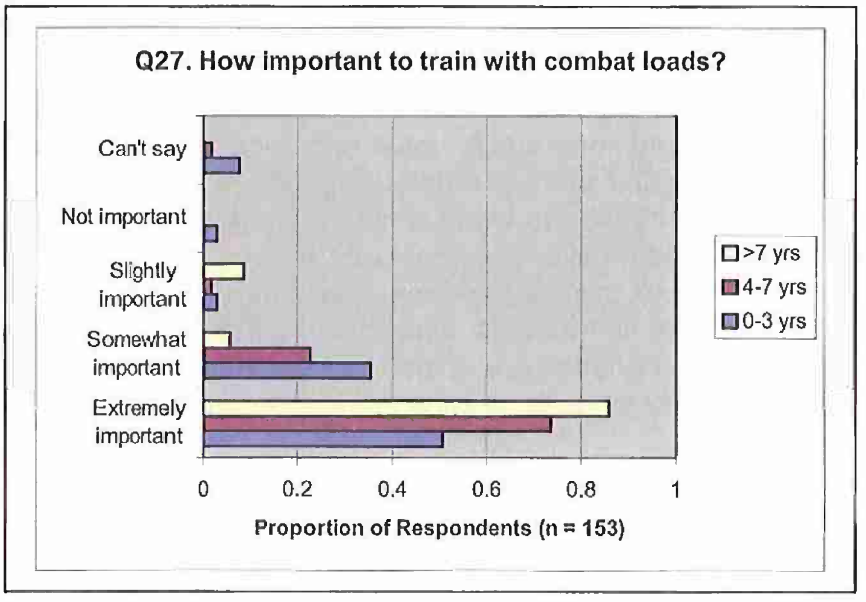

Figure 26. Importance of Training with Combat Loads.

Figure 27 displays placement preference when an item does not fit inside the ruck. Seventy-four percent of total respondents stated that they would put an item on top of the ruck if it didn't fit inside. Only respondents with 0-3 years experience suggested putting items under or on the outside back of the ruck. Placing items on the side of the ruck was minimally suggested by 5.9 percent of the total respondents. Approximately thirteen percent of total respondents reported uncertainty in this situation.

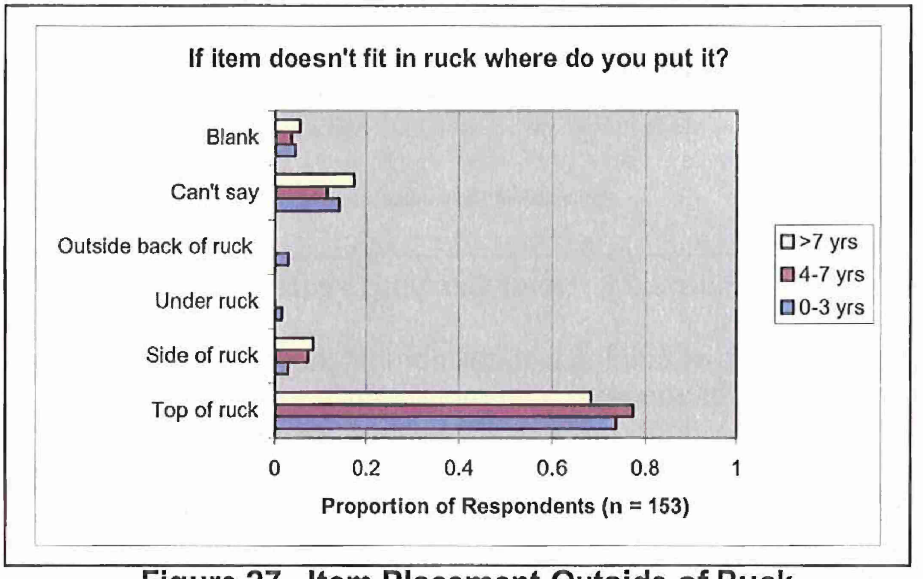

Figure 27. Item Placement Outside of Ruck.

Figures 28 and 29 address time and control over making the load comfortable. Sixty-six percent of respondents with more than 7 years military experience, fifty-five percent of respondents with 4-7 years military experience, and forty-nine percent of respondents with 0-3 years military experience reported spending a great deal of time making the load comfortable. Despite the reported time spent making the load comfortable, most respondents indicated that they only have some control (47.7 percent of total respondents). Respondents with 0-3 years military experience reported less control on making the load comfortable than respondents with more military experience. Approximately thirty percent of respondents with 0-3 years military experience said they do not have much control in making the load comfortable, while only 13.2 percent of respondents with 4-7 years military experience and a mere 8.6 percent of respondents with more than 7 years military experience reported having hardly any control.

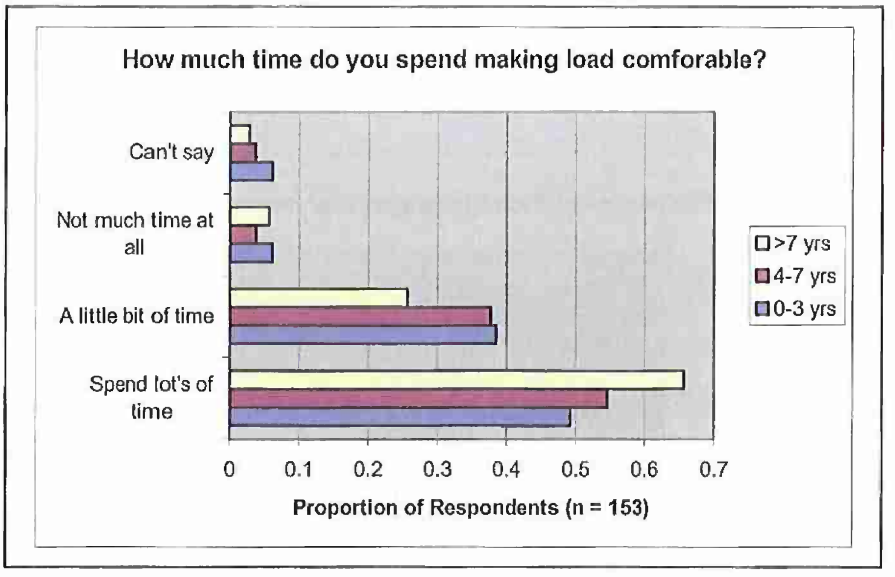

Figure 28. Time Making Load Comfortable.

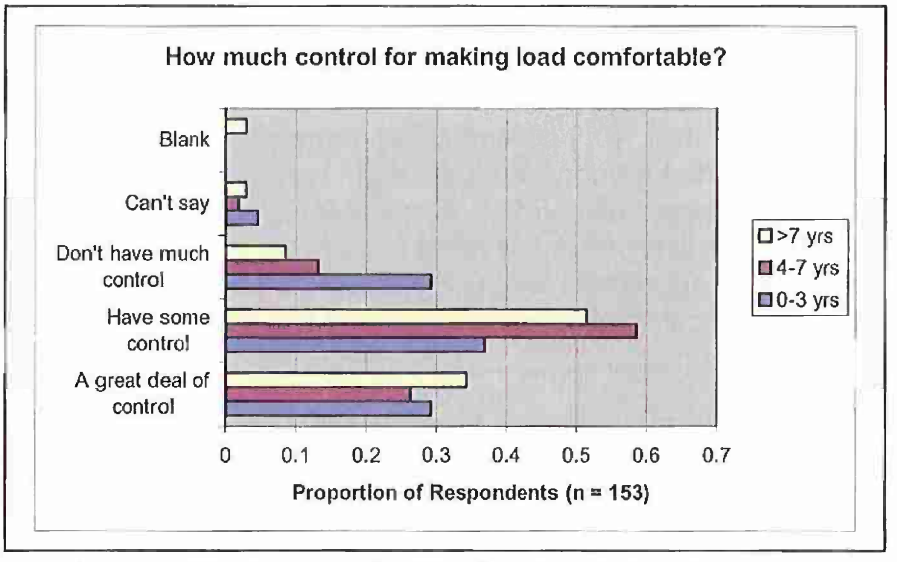

Figure 29. Control for Making Load Comfortable.

Figures 30 and 31 present responses about relative discomfort in the mid and lower back after prolonged marching with loads. For mid back discomfort, thirty-six percent of all respondents reported moderate discomfort, thirty-three percent reported great to extreme discomfort, and twenty-two percent reported slight to some discomfort. Respondents with 0-3 years experience were significantly more likely to report moderate discomfort (50.8 percent) than respondents with 4-7 years experience (22.6 percent) and respondents with more than 7 years experience (28.6 percent). Respondents with more than 7 years experience were more likely to report some mid back discomfort (31.4 percent) than those with 0-3 years experience (13.9 percent). In contrast, respondents with more than 7 years experience were less likely to report great

mid back discomfort (8.6 percent) than those with 4-7 years experience (28.3 percent).

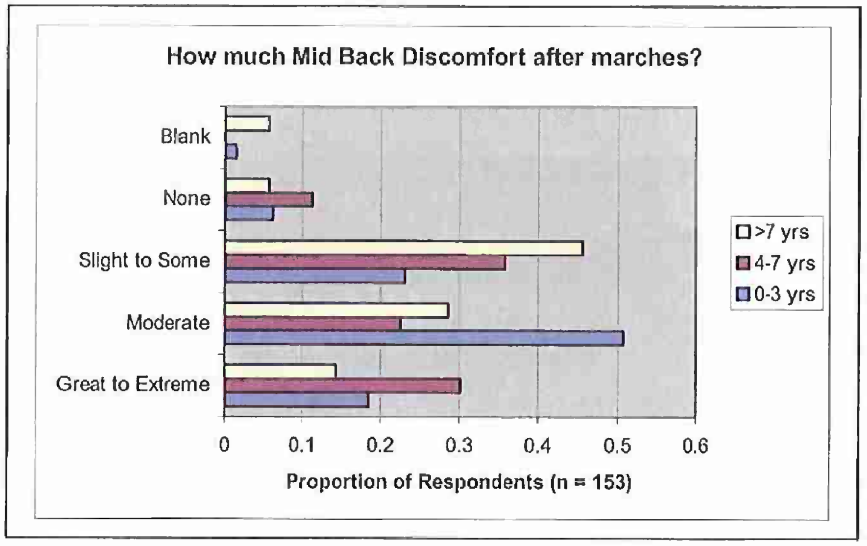

Figure 30. Mid-Back Discomfort.

For lower back discomfort, 40.5 percent of all respondents reported great to extreme discomfort, 29.4 percent reported slight to some discomfort, and 18.3 percent reported moderate discomfort. Respondents with 4-7 years experience were significantly less likely to report great to extreme lower back discomfort (16.9 percent) than respondents with 0-3 years experience (55.4 percent) and respondents with more than 7 years experience (48.6 percent).

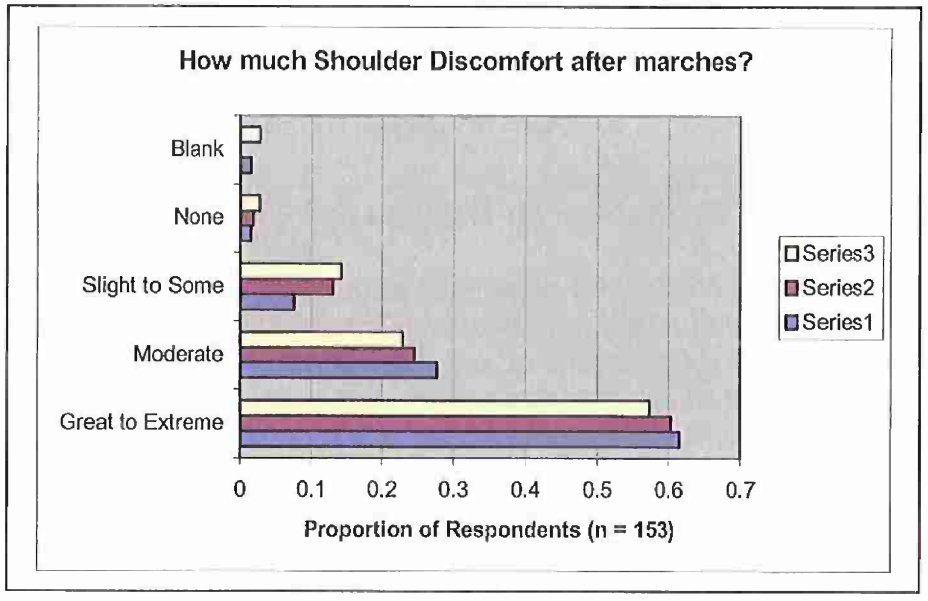

Figure 31. Lower Back Discomfort.

The majority of respondents (60.1 percent) reported great to extreme shoulder discomfort after prolonged marching, as shown in Figure 32. Approximately twenty-six percent of all respondents reported moderate discomfort, 11.1 percent reported slight to some discomfort, and 2.0 percent reported no shoulder discomfort.

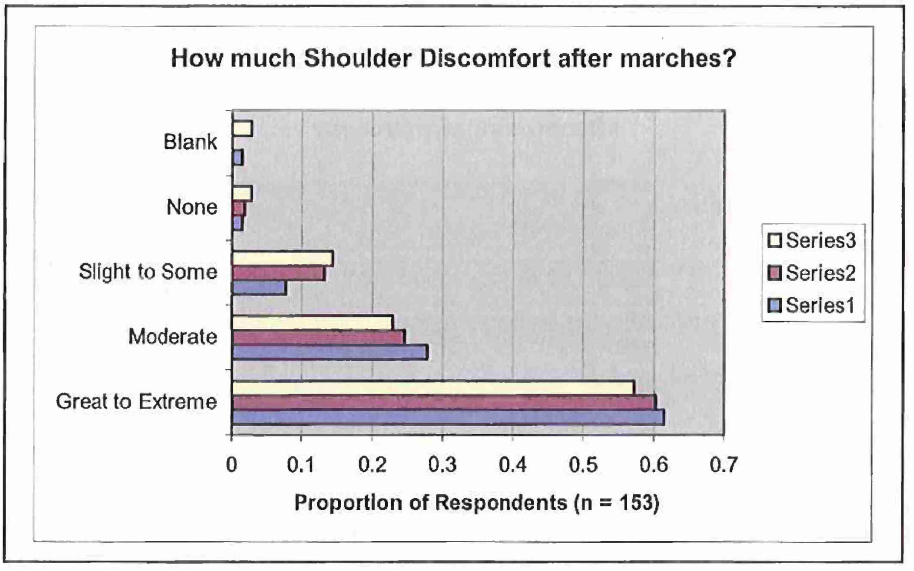

Figure 32. Shoulder Discomfort.

Figure 33 addresses feet discomfort after prolonged marching. Thirty-five percent of respondents reported great to extreme discomfort, 28.1 percent reported moderate discomfort, 26.1 percent reported slight to some discomfort, and 10.5 percent reported no discomfort.

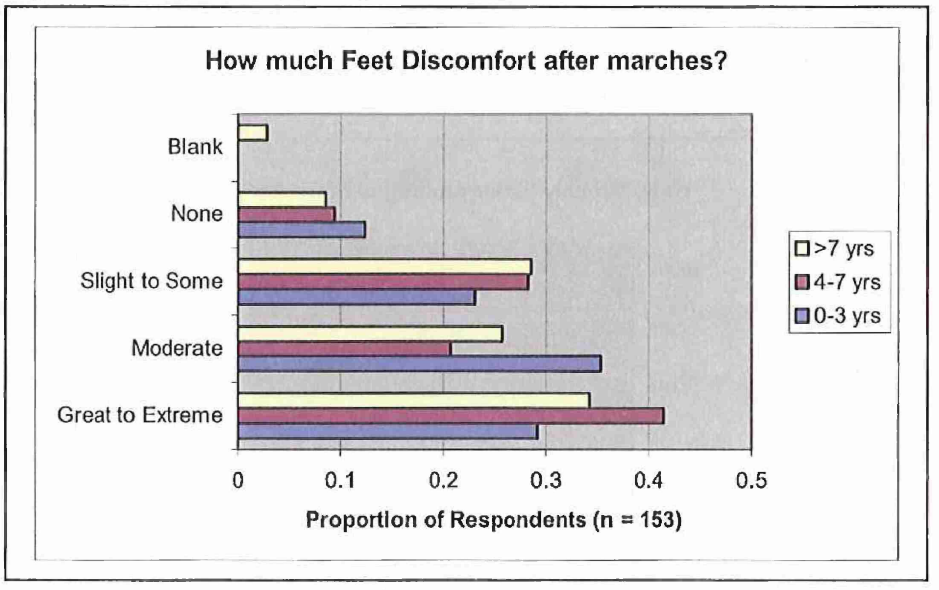

Figure 33. Feet Discomfort.

Figure 34 suggests that the discomfort from heavy loads does not adversely affect mental concentration. Forty-two percent of total respondents indicated no difficulty concentrating after a prolonged march, and 38.6 percent of total respondents indicated slight to some difficulty concentrating after a prolonged march. A mere 9.2 percent of total respondents indicated great to extreme difficulty with concentration.

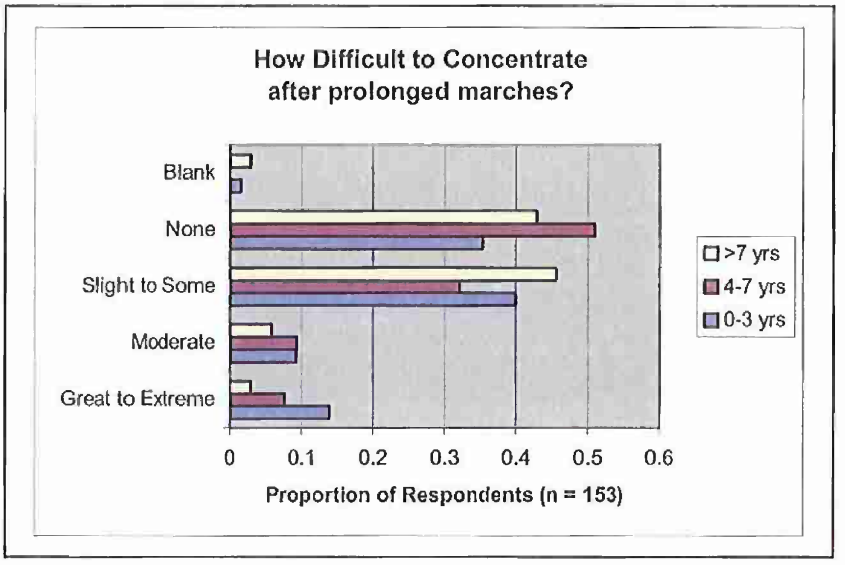

Figure 34. Concentration after Prolonged Marching.

Self-assessment of stability after prolonged marching is shown in Figure 35. Approximately fifty percent of total respondents reported slight to some loss of stability after prolonged marching. Respondents with more military experience tended to report greater maintenance of stability (35.9 percent of respondents with 4-7 years of military experience reported no loss of stability in comparison to 18.5 percent of respondents with 0-3 years military experience).

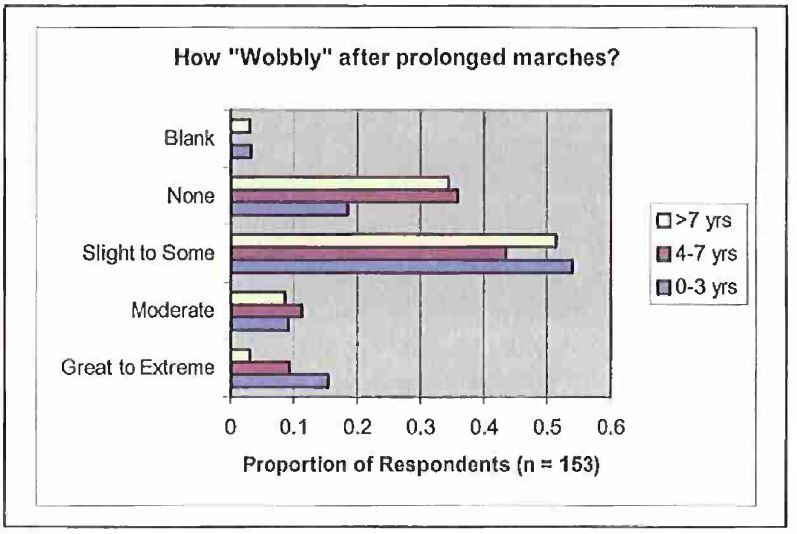

Figure 35. Stability after Prolonged Marching.

Figure 36 addresses the tendency for gait to be altered after prolonged marching while load bearing. Seventeen percent of total respondents reported great to extreme likelihood for altered gait, 22.2 percent of total respondents reported moderate likelihood for altered gait, 39.2 percent of total respondents reported slight to some likelihood for altered gait, and 19.6 percent of total respondents reported no tendency for altered gait. Respondents with 4-7 years military experience were more likely to report no tendency for altered gait (28.3 percent) than respondents with more than 7 years military experience (8.6 percent). Respondents with 0-3 years military experience were less likely to report moderate tendency for altered gait (16.9 percent) than were respondents with 7 or more years (37.1 percent).

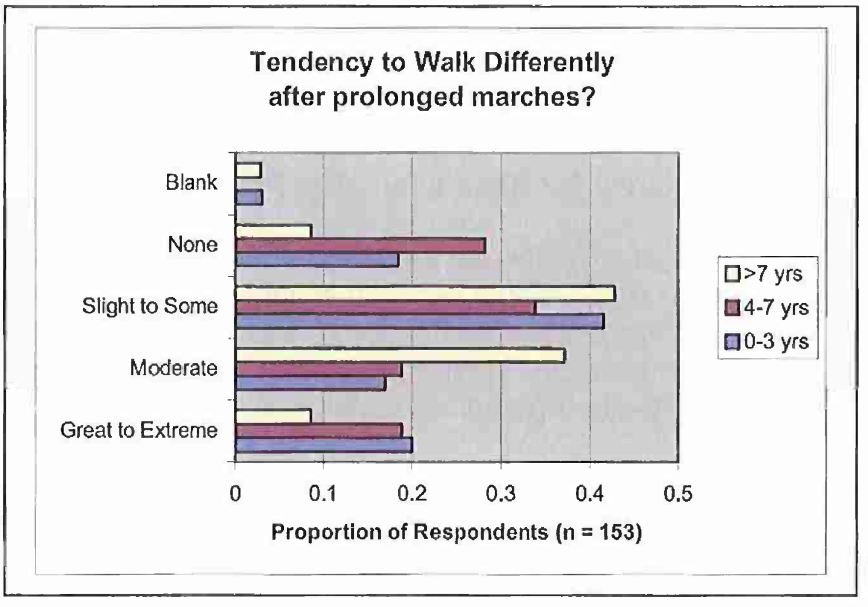

Figure 36. Tendency for Altered Gait after Prolonged Marching.

Figure 37 illustrates the tendency for head lean after prolonged marching. Thirty-one percent of all respondents indicated no drop of the head after prolonged marching. Thirty-one percent of all respondents also indicated slight to some leaning of the head. Only 12.4 percent of total respondents indicated great to extreme head lean. Of those who indicated great to extreme head lean, 63.2 percent were respondents with 0-3 years military experience.

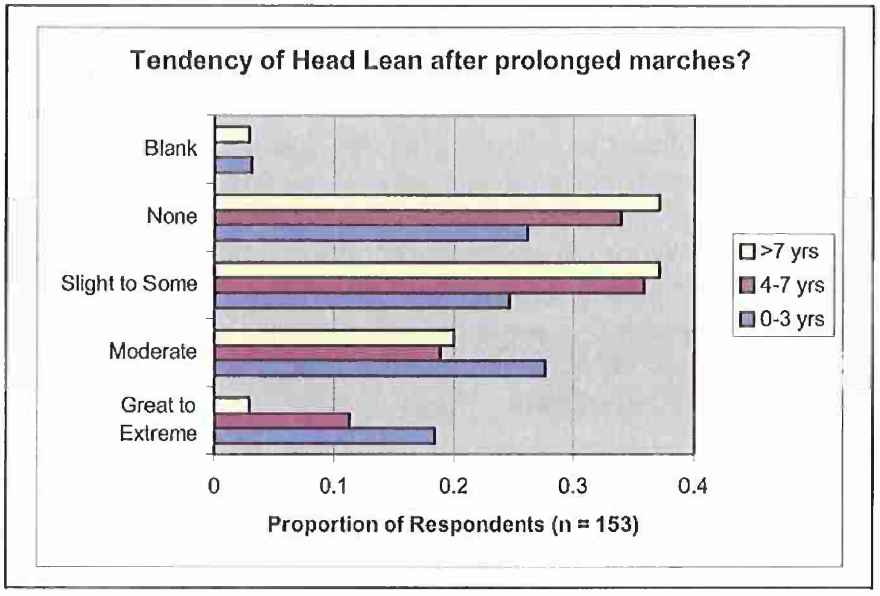

Figure 37. Tendency for Head Lean after Prolonged Marching.

Postural changes after prolonged marching are shown in Figure 38. Thirty-three percent of all respondents reported slight to some postural bending, 24.2 percent reported moderate postural bending, and 20.2 percent reported great to extreme postural bending. Respondents with 0-3 years military experience were most likely to report great to extreme tendency to be bend over (29.2 percent).

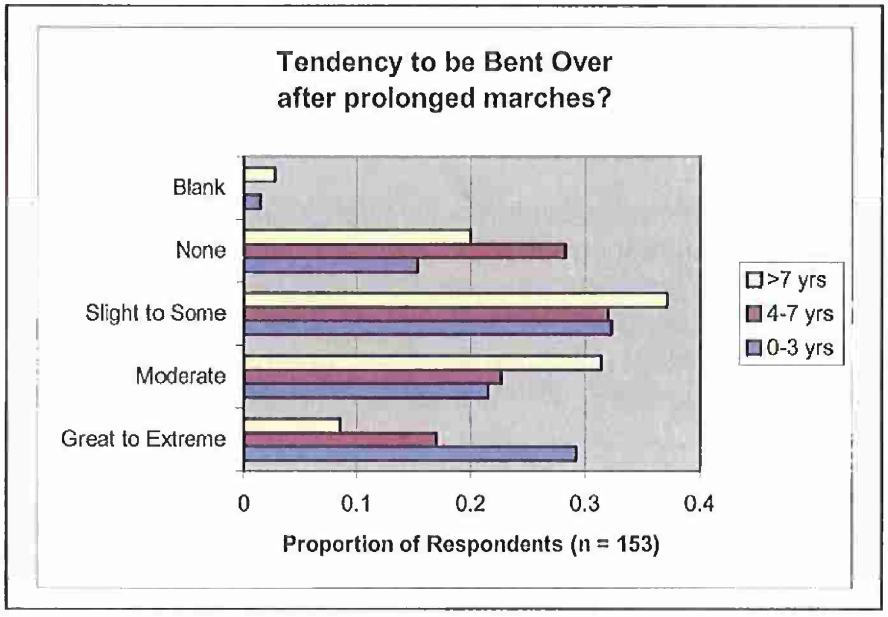

Figure 38. Tendency to be Bent Over after Prolonged Marching.

SOLDIER COMMENTS TO QUESTIONS

In response to the question "Have you had any special load carrying training or experiences? If yes, explain or describe (e.g. what, where, when)," twenty-two respondents indicated combat operations in Afghanistan. Six respondents answered combat operations in Kosovo, Haiti, Panama, or Hawaii. Sixteen respondents noted experience in Army training and service (Ranger School, JRTC, Special Forces Selection, etc.), and six respondents specifically noted training at Fort Bragg, Fort Polk, or Fort Benning. Three respondents stated civilian backpacking training. Thirteen respondents listed the MOLLE, and six listed combat essential items such as rucks, assault packs, etc.

When asked if they had ever deployed into a combat zone with a fighting load, ninety respondents indicated Afghanistan. Thirteen reported deployment in Kosovo, Haiti, Somalia, Bosnia, Korea, Panama, or Honduras. Five respondents indicated deployment to Saudi Arabia/Operations Desert Storm & Desert Shield/Iraq. Twenty-six respondents listed carrying the MOLLE ruck and assault pack, but only one listed the ALICE pack. Twenty-six respondents reported various load carrying systems and devices, including the London Bridge Assault Pack, IBA, LBV, full combat load, body armor, and the M82 aid and assault bag. Five respondents responded vaguely with "combat missions," and four respondents stated, "I would, but I'd have to kill you."

Regarding previous civilian backpacking experience, thirty respondents indicated hiking and backpacking experience. Seven indicated camping, and ten indicated experience rock climbing, biking or riding motorcycles, hunting or fishing, or scouting. Twenty-one respondents reported experience with an internal frame ruck, and four reported experience with an external frame ruck. One respondent stated, "Civilian backpacking has no real reference to what we do- a couple hippies on the Appalachian Trail are not wearing body armor."

When asked about favorite or preferred type of load carrying system, twenty-seven respondents indicated the ALICE pack and frame. Eleven additional respondents indicated the ALICE pack with the H-harness, LBV, or extra pockets and modifications. Seven respondents indicated the MOLLE, and three indicated the MOLLE with LBV. Seven indicated Blackhawk or London Bridge Patrol packs, and twenty-three indicated other load systems.

Respondents were asked the question "is it advisable to place items so weight is distributed equally, to your front and back, as much as possible?" Ten suggested putting most of the weight on the back, five suggested putting the weight as high on the body as possible, and two suggested putting the weight as close to the body as possible. Five stated that too many items on the front hinder movement, and one suggested that rounds and weapons should be carried in the front with the ruck in the back. Seven indicated that weight should be distributed

to make it comfortable for each individual. Two responded that weight should be distributed equally between front, back, and shoulders.

When asked "is it advisable to place items so weight is distributed equally, to your left and right, as much as possible," six respondents stated that the load should be balanced and distributed evenly. One respondent indicated that if the load were not distributed, it would be painful. Similarly, one respondent indicated that if the load were not balanced, it would be unstable. One respondent declared that "the pressure is then on your hips, not your back," and one stated, "the MOLLE ruck portion is too small to distribute anything." One respondent replied, "If you were traversing across a slope, you would want the weight on the upside of the slope to avoid being pulled to the down side."

In response to the question "is it advisable to place items so weight is distributed equally, top to bottom?," thirty-two respondents indicated that heavy weight should be placed on top. Four responded that weight should be close to the back, and three suggest distributing items and weight throughout the pack and body. Three respondents suggested putting heavy weight near the bottom.

Respondents were also asked if heavy items should be placed close together. Six respondents suggested spreading them out evenly through the pack. Four suggested putting heavy items close to the back, and one suggested putting heavy items close together. Five suggested putting heavy items on the top of the pack, and one stated that it is access verses weight distribution.

When given the prompt "from your experience, where is the best place to put heavy items," nine suggested close to the frame. Twelve responded near the top of the ruck; in juxtaposition, three responded near the bottom of the ruck. Three stated that it depends on what and how an item is being used. Two suggested that heavy items should be left behind, and four said heavy items should always be kept inside the pack, never hanging off the pack.

Respondents were asked about how they typically carry their rucksack. Four indicated using the waist strap, but three said they rarely use and do not recommend the waist belt. Five expressed that it is difficult to use the waist belt because it does not fit properly with other equipment and prevents quick removal of the ruck. One respondent said he would use the hip belt if it were padded, comfortable, sturdy, and convenient. Two indicated using the chest strap, and one indicated attaching shoulder pad cushions to the shoulder straps. Two responded that it depends upon the type of movement.

In response to the question "with heavy loads, do you tend to keep straps, pouches and items attached loose or tight?," ten said they keep everything tight in order to keep equipment from bouncing and shifting. Four responded that they keep things tight, but loosen when necessary for better circulation. One stated "I carry the ruck on my shoulders with straps loose and kidney pad hanging below

my waist," and one responded, "The MOLLE attaching pouches don't stay tight without the bungee cord." Another respondent expressed that though the load should be close to the back, it is difficult with the IBA.

Respondents were asked if they "tend to maintain a *fixed arrangement or position* of your load system on your back/shoulders or do you try to *vary it* during a march?" Six indicated that they hike the load up during the march to take weight off the shoulders and prevent arms from going numb. Similarly, one responded that keeping the pack in one place causes discomfort. One declared that he does not vary arrangements during a march, only before a march. Another respondent stated that it depends upon how long the movement is and the weight of the load.

In response to the question "if your movement was largely UP hill, how would you prefer the load be arranged?," two responded high and close to the frame. One respondent said, "Once you are packed and the load is tight, it doesn't matter if it's up or down hill." Two lamented, "It's going to be bad no matter what." Conversely, when asked about load arrangement during DOWN hill marches, three responded "high." One indicated that the load should be centered and close to the frame. Another respondent said, "In reality, you would never repack the load."

When asked "would you prefer a *long & narrow* ruck over a *short & wide* ruck for long marches?," two respondents suggested a short, wide ruck because it doesn't dig into your legs and allows you to pack your weight evenly. Five stated that a long, narrow ruck would not fit with body armor, or adjust for people of varying heights. One said it depends upon the vegetation, and two stated, "It doesn't matter as long as it fits the soldier in body armor and LBE, and keeps the weight above the shoulders." One declared that "the ALICE pack is good enough," and two labeled the MOLLE frame as too long and awkward.

On soft or difficult ground (loose dirt, rocks, sand, snow) that can't be avoided, six respondents would prefer to slow down. Three indicated that it depends upon the situation, and one responded that he would follow the team leader's pace. One suggested getting into a truck or helicopter, and two were concerned about conserving ankles and knees. Another respondent indicated worry about leg fatigue and injury.

With heavy loads, seven respondents indicated that they prefer to keep footwear tight because it provides more ankle support and stability. Three stated that if footwear is loose, it might cause blisters. Six responded that they prefer snug footwear- not too loose or too tight. When asked about the weight of the footwear (heavy or light), three respondents suggested they like light footwear with a good sole and ankle support. One commented that "heavy boots are even heavier when wet," and another respondent stated that light boots dry more

quickly. One indicated a preference for the new desert Air Force Boots, and yet another liked the Marine Corps Desert Jungles.

When faced with going over a hill with a heavy load, four respondents indicated that preferred movement pattern depends upon the slope and the situation. Four preferred to move in a zig-zag pattern. Though one respondent stated, "most other animals in nature would never go straight over a mountain because they have common sense," another proposed "one and done, shortest distance." One suggested using spurs, and another respondent commented, "The Afghan hills/mountains are unforgiving either way."

In response to "how important is it to you to have well broken-in footwear for prolonged marches?," four indicated that it was crucial. Three respondents stated that new boots cause blisters, and one suggested that footwear too old or too new is bad for the feet. One responded that socks are probably more important.

Respondents were asked "How important is it to keep most of the weight near the center of your body and reduce the weight in the hands and on the legs and feet?" One responded that it is important for blood circulation, and one indicated that legs should have a good range of motion. Another respondent declared "I like a high, centered load with hands free and nothing around my neck."

When asked "do you prefer to shift the weight of the rucksack around during the march or maintain the load in the same position throughout?," only one respondent preferred to maintain the same position. Three indicated that they shift the shoulder straps and "ruck hop," and three said they shift constantly because the weight pulls in one place.

Respondents answered the question "how important is it to train with the same weights and types of loads to be expected in combat?" Two declared you should train as you fight, and four indicated that training should be done with body armor, ruck, and assault pack. One responded that it is good practice for stability and maneuverability. Three suggested that if soldiers are seasoned and mentally tough, weight in training is less important because "you don't have to practice being miserable- you get it right the first time." Five suggested that it is advantageous to train heavy and fight light.

If equipment will not fit inside the ruck, twelve respondents indicated that the type of equipment and situation would determine how it would be secured. Five suggested that it would be secured primarily on the top and side. Five respondents said that it could be secured anywhere, and one responded, "Bury it." One stated, "we normally do not pack much more than the ruck can hold," and another respondent declared, "MOLLE does not have enough space for equipment."

When asked "how much attention do you give to making your load comfortable," four responded that usually there is very little time. Three said that it depends on the time available and the necessary equipment. Three respondents declared that it's going to be uncomfortable regardless, but yet another three stated "I make it as comfortable as I can."

In response to the question "how much control do you have on making your load comfortable, ten respondents stated that it depends on the mission objective, available time, and necessary equipment. Five indicated that as long as you have everything necessary for a mission, you can place it where you like. Three respondents indicated very little control because packing lists usually overfill the pack. One respondent declared, "I'm a platoon sergeant!"

Respondents were asked, "How much overall discomfort do you generally experience at the end of a prolonged march?" Three reported a great deal of discomfort, but one expressed that the discomfort basically stops once the march is over. Two respondents reported fatigue and exhaustion, but also feeling "really good." One indicated discomfort due to spinal compression, particularly with the MOLLE. Two respondents indicated that the amount of discomfort depends on the distance, duration, terrain, and load.

OPEN-ENDED QUESTIONS ON LOAD CARRYING

Respondents were asked about the key advantages and disadvantages to external frame pack systems. Eight reported more space to pack items, and two reported the ability to tie items to the frame. Seven mentioned that external frame packs are stronger and offer more stability. Four stated that they offer better ventilation to the back, making heat control easier to manage. Four indicated that the external frame moves less on the back, and three claimed that external frame pack systems offer more support for the back. Six mentioned that they are easier to repair and replace. Four declared that they are more comfortable, while seven thought the external frame was less comfortable. Four listed durability as an advantage, but five listed poor durability as a disadvantage. Four stated that the external frame is easily adjusted and put on, but one stated that it is difficult to adjust. Seven indicated that the external frame pushes the load far away from the body, shifts easily, and hangs on the shoulders. Two stated that it is heavy and catches on equipment. Three suggested that longer, wider shoulder straps with a padded chest strap would improve the comfort of the external frame pack system.

Respondents were also asked about the key advantages and disadvantages of the internal frame pack system. Twelve respondents stated that it is more comfortable, while three respondents stated that it is less comfortable. Two mentioned greater durability, while five mentioned reduced durability. Six indicated that the internal frame pack system offers less room in the pack. Seven stated that the internal frame pack system offers a better fit

(more support and padding) and three stated that it is easy to adjust, while two contested that it is difficult to adjust and two stated it is difficult to fix. Three respondents indicated that it provides greater stability, two declared that it is lightweight, and one stated that it is easy to pack. One contended that the internal frame pack system is well balanced, while one stated it is poorly balanced.

In response to the question "what problems might be expected if weight in the rucksack is packed too high?," twenty-nine respondents stated they would become off-balance and unstable, thus likely to fall. Eleven respondents indicated that one would become top heavy, and ten reported a tendency to lean forward and march in a hunched position. Forty-seven stated back, shoulder, hip, and neck pain/problems, while eleven declared there would be no problems. One expressed "the higher the weight the better," but another respondent warned that the load would catch on things in the environment. One respondent indicated an inability to lie in the prone position and lift the head, and one indicated that the movement would be slow. One respondent stated that the frame would break, one expressed that the pack would be difficult to put on and remove, and one warned that the pack would shift left and right.

When asked "what problems might be expected if weight in the rucksack is packed too low?," ninety-eight respondents indicated back (upper and lower), shoulder, hip, and leg discomfort and problems. Twelve stated that it pulls your shoulders down and back, making you feel as though you are dragging, and one respondent indicated that it makes your arms go numb. Five indicated instability and disrupted walking patterns, while two indicated no problems at all. Three responded that it would cause increased fatigue and discomfort, and one responded difficulty going uphill. One stated that you would lack the necessary equipment (he must have understood the question to mean "packed too light").

Respondents were asked about what problems to expect if the load is not well balanced. Fifty reported more pressure, pain, and fatigue in one side of the body. Forty-five indicated loss of stability and difficulty walking. Ten stated discomfort, and twenty more specifically listed shoulder, back, neck, hip, or leg pain. Six indicated shifting of the load, and two indicated that it would yield poor performance and decreased effectiveness. Four stated that it would cause fatigue, four stated arm numbness would be expected, and one stated that movement would become uncomfortable and restricted.

Respondents were asked the question "what problems might be expected if the load is loosely packed?" Fifty-six responded that it would cause the load to shift. Twenty-one indicated that loosely packed loads would lead to loss of balance, and seventeen indicated that it would lead to increased discomfort. Seven respondents mentioned back and shoulder pain, three mentioned that the skin would be rubbed raw, and five mentioned increased fatigue and impatience. Three indicated a loosely packed load would make noise, and one indicated that

it would cause a decline in performance. Seven respondents stated that it would cause equipment to be lost, five stated that all gear would not fit in the pack without looking "bulky," and one stated that the load would feel heavier.

When asked if "prolonged marches tend to impact your other duties as a soldier," eighty-seven respondents declared "no" while fifty-four responded affirmatively. One respondent who responded negatively suggested that marches would impact other duties if one has blisters. Twenty-nine respondents who responded "yes" noted that prolonged marches lead to fatigue, soreness, and decreased concentration. Seven respondents also noted decreased situation awareness and reaction time for jobs such as security. Other respondents mentioned dehydration, blisters, decreased motivation, short-temper, and decreased ability to move. One respondent declared, "yes, but it's my job- so I do it." Another respondent stated "yes, long marches take a lot out of a person and we become physically 'smoked,' but in my MOS regardless of physical condition after a long march the end state is to complete the objective and LIVE. So no one fails their duties!"

CONCLUSIONS AND RECOMMENDATIONS

This survey was designed to determine infantry soldier preferences and understanding of load carrying techniques relative to their requirements for executing combat missions. The surveyed soldiers were involved in combat action in Afghanistan in April 2003. The respondents of this survey are highly representative of infantry units in the Army in general, in terms of their Military Occupational Specialties (MOS) and background demographics. One hundred thirty-nine respondents were infantry enlisted men (MOS 11B), four respondents were infantry officers (11A), and five respondents were medics (91W). Most (68%) were under 26 years old and nearly half had less than 3 years of military service. Knowledge gained from this survey of respondents' preferences and understanding of load carrying can be projected as the preferences and understanding of the general infantry soldier in the US Army at the time of the survey.

As might be expected, research suggests that the effectiveness of load carriage is a function of experience (Vacheron et al., 1999). Thus, to assess the influence of experience on judgments about how to carry loads, soldiers were divided into three subgroups according to years of military experience. The number of soldiers in the three groups was large enough to allow statistical comparisons. The groupings appear to represent relevant blocks of experience. The first group (0 to 3 years) would be expected to have little to no experience in carrying combat loads while those in the last group with more than 7 years would be expected to have considerable knowledge and intuitive understanding of tactical load carrying techniques. The results appear to confirm expectations. The responses to many of the items in the questionnaire were different for soldiers with 0-3 years experience as compared to soldiers with 4-7 years experience and to soldiers with more than 7 years experience.

In terms of equipment preferences, soldiers with less experience were not as likely to report a load system preference. This subgroup also tended to report neither a preference for light or heavy footwear, nor a preference for keeping straps, pouches, and items tightly or loosely attached. Soldiers with less experience may not voice preferences because they lack the experience with different systems and limited experience with any one system. At this point in their career, they generally rely on the direction of the more seasoned soldiers. With less exposure to different types of equipment and situations, soldiers with less experience may not have developed preferences or experimented with adjusting equipment for optimal performance.

Similarly, those with less experience may lack an intuitive biomechanical understanding of load carrying because they have limited first-hand operational experience with actual combat loads. Soldiers with less experience were more likely to suggest that heavy weight should hang off the back of the ruck. They were the only subgroup that did not suggest putting heavy items on the top of the

ruck. Loads arranged with the weight hanging off the back of the ruck pull downward on the lower back, causing discomfort and altered gait. Lower back problems are a frequent cause of inability to complete strenuous marches (Knapik et al., 1997). Heavy items that do not fit inside the ruck should be placed on top of the ruck near the frame because loads carried near the body's center of gravity require the least amount of energy to carry (Knapik, Harman & Reynolds, 1996). Less experienced respondents may not have encountered a situation where heavy items did not fit into the ruck.

The less experienced soldiers were also more likely to suggest that weight should be distributed evenly top to bottom. Load researchers suggest weight in the ruck should not be too low or too high on the back. They recommend that the load should not hang below the center of the body mass because that may cause lower back stress and discomfort. If the weight of the load is too low in the ruck, forward lean increases, bringing the center of mass over the front half of the foot and possibly heightening the chance of foot injury (Knapik, Harman & Reynolds, 1996). In addition, low loads can inhibit leg motion and sway excessively from side to side, causing a loss of balance. Conversely, if the weight of the load is too high in the ruck, body sway increases and posture destabilizes (Knapik et al, 1996). When unexpectedly stumbling, high muscles forces are needed to counter the momentum created by the highly placed load. Mid-back placement is preferable because it requires lower levels of periodic activity in the back muscles and allows for less movement of the load (Bobet & Norman, 1984). During a stumble, less force is needed to off-balance inertial and gravitational movements (Bobet & Norman, 1984).

Soldiers with less experience were uncertain about the placement of heavy items within the ruck (i.e. whether items should be kept close together or spread apart). In general, soldiers with less experience were more likely not to prefer any of the answer choices. They were also more likely to indicate that it does not matter how a piece of equipment is used or how the load is carried. Infantrymen with less experience were more likely to dismiss the question of how the load is carried up or down hills as unimportant. This probably stems from a lack of general knowledge or intuition about load carrying and basic biomechanical principles.

The less experienced soldiers were not as likely to report control in making the load comfortable. This may be due to their military rank as lower ranked soldiers are often told how to configure their load. Load configurations are often part of unit standard operating procedures. Another explanation may be the tendency for less experienced soldiers to report greater discomfort and adverse affects from load carriage no matter what they do. Without skill in load arrangement, they may not understand how to lessen the discomfort, and view the situation as if no improvements can be made. Less accustomed to the demands of load carrying, these soldiers may be attending more to aches and pains. Indeed, these soldiers were more likely to report moderate-to-great mid

back discomfort. They were more likely to indicate great-to-extreme head lean as well as great-to-extreme tendency to be bent over after prolonged marching. This, as mentioned earlier, may be related to the reported inclination of these soldiers to hang items off the back of the ruck. In the end, soldiers with less experience may feel they have less control because they are unable to affect a change to their discomfort with loads.

In contrast to the soldiers with less experience, those with more experience were more likely to report a load system preference. The more experienced soldier may be more adept at making adjustments and carrying the load in a biomechanically advantageous way. In fact, a significant proportion of the respondents with more experience strongly supported keeping heavy items together inside the ruck. Grouping heavy items helps to maintain a load arrangement that is centered right to left. Such an arrangement reduces the shifting of the ruck, diminishing body instability during movement and reducing the likelihood of injury.

Soldiers with more experience were the only subgroup of infantrymen to advise carrying the weight on the hips as well as the shoulders. By distributing the weight between the shoulders and the hips, less weight hangs down from the shoulders and pulls on the lower back. Use of a hip belt reduces the load on the shoulders and the incidence of some injuries, as well as the perceived strain (Knapik, Harman & Reynolds, 1996). Reported use of the hip belt may connect to the greater maintenance of stability after prolonged marching reported by respondents with more military experience.

The more experienced soldiers preferred slowing their movement while traveling through soft ground. Research by Crowell et al (1999) suggests that although soldiers tend not to perceive that terrain has an effect on workload, terrain significantly affects performance (Givoni & Goldman, 1971). Type of terrain has significant influence on energy cost (Goldman & Iampietro, 1962; Goldman, 1965; Pandolf, Givoni & Goldman, 1977; Knapik, Harman & Reynolds, 1996). Traveling over soft or lose ground increases physical effort and fatigue. It is, thus, inadvisable to require soldiers to maintain the same rate of movement while on soft ground. As the evidence shows, slowing over difficult terrain conserves energy and may prevent injury. However, the dilemma for the soldier is that slowing may be tactically dangerous in open terrain, giving the combat infantryman little choice other than to move as rapidly as possible at the risk of becoming physically fatigued.

Soldiers with more experience seem to understand the demands of actual combat, therefore tending to emphasize the greater importance of realistic load training. Those with more military combat experience understand the importance of being fully trained and prepared for the physical as well as mental challenges of engagement with the enemy. Realistic combat training allows soldiers to become more accustomed to equipment and standard operating procedures.

Furthermore, in theory, highly trained and conditioned soldiers would have a lower cognitive load. This frees the soldier to pay more attention to critical details of combat and to be less distracted by the dynamics of load carrying. Research suggests that training with loads naturally results in greater physiological energy efficiency (Knapik, Harman, and Reynolds, 1996). Greater physiological energy efficiency logically benefits cognitive performance as well. For the Army, greater focus on realistic load training would be expected to significantly improve overall performance in combat.

Although soldiers with different levels of experience differed in general knowledge about load carriage, they did not differ in their responses to specific items. Across all levels of experience, the ALICE pack was preferred. Previous research suggests that soldiers find the ALICE pack well balanced, stable on the body, and easy to adjust (Knapik et al., 1997). In general, short, wide rucks were favored over long, narrow rucks. The preference for ALICE among soldiers with less experience may result from less experience with the MOLLE and/or being influenced by the more senior soldiers who have a bias for the legacy equipment. Determining the source of this preference would require a carefully designed study to tease out the impact of prior experience.

Another area of agreement among soldiers to this survey is in the distribution of load. Most advised distributing the load evenly left and right as well as front and back, which is relatively intuitive even for those with little experience. However, they also recommended keeping the load off the hands and the feet, which is not intuitive. This may reflect knowledge of the added energy cost of carrying weight in the hands and on the feet, or awareness of operational demands is not clear. Research shows that added weight in the hands increases energy cost two fold while added weight to the feet increases it four fold (Soule & Goldman, 1969). However, soldiers may have considered tactical reasons for not preferring these locations. In combat situations where survival is key, soldiers cannot be hampered in their movement due to hand-held equipment or items dangling on the lower legs or feet (Sampson, 1988).

Most soldiers agreed that items should be tightly attached to the ruck. In their comments, they advised that items be securely attached to prevent shifting or loss of equipment. Most also thought the weight should be carried primarily on the shoulders. However, research suggests that carrying the load primarily on the shoulders is not recommended. When the load is carried on the shoulders, soldiers report more subjective discomfort than when the weight is carried primarily on the waist (Knapik, Harman & Reynolds, 1996). The soldiers may have reported primary use of the shoulders to carry the load because the older load carrying systems were not designed to distribute part of the load to the hips or because of tactical reasons where hip belts tend to prevent rapid response to enemy fire (Sampson et al., 1995). The reason for soldiers' inclination for shoulder carriage needs further exploration to aid in rucksack design and development.

Features in the new MOLLE system provide for better load distribution to the hips, but may not be utilized by soldiers if hip belts are tactically encumbering or unsafe (Sampson, 2001).

In contrast to the strongly reported preference to carry the weight primarily on the shoulders, respondents showed no preference as to whether the load should be maintained in one position or varied throughout a prolonged march. Here it is not clear whether respondents fully understood the question being asked. If soldiers thought "maintaining one position" meant that the configuration within the ruck should remain the same, responses would be different than if the question meant not shifting the position of the rucksack on the shoulders during a march. If all the soldiers understood the question to be asking whether they should shift the load on their torso in order to avoid fatiguing certain muscles, then there might have been more agreement favoring dynamically changing the load position. Indeed, research by Knapik, Harman & Reynolds (1996) suggests that shifting the load and distributing it from one body part to another during marching may reduce strain and pressure. The wording of the question needs to be investigated for application to future surveys.

Although no decisive preference is indicated about shifting the load, regardless of experience level, soldiers claimed to spend a great deal of time making the load comfortable. It was not specified whether this refers to the time spent arranging equipment in the ruck before marching begins, or adjustments made throughout the march by adjusting the placement of the ruck on the back. Despite significant time reported for making the load comfortable, soldiers described great-to-extreme shoulder discomfort. Shoulder discomfort may be inevitable due to the stress of prolonged marching with heavy loads.

Across all levels of experience, soldiers of this survey agreed about how to adjust their footwear. Clearly they preferred tightly tied boots so as to prevent blistering from foot slippage in the boot. Similarly, they valued boots that are well broken-in. Nearly all the soldiers favored lighter verses heavier boots. Boots made of lighter material would be expected to cause less leg fatigue (Soule & Goldman, 1969). After extended marching, lighter-thinner boots may allow heat and sweat to escape more rapidly. These boots tend to be more flexible, molding better to the foot while providing adequate support.

Most soldiers in this survey indicated that discomfort from heavy loads does not significantly and adversely affect mental concentration. The only evidence we might have to support the soldiers' claims of no decline in performance comes from research by Knapik et al. (1997). This research suggests that cognitive ability, marksmanship, and grenade throwing accuracy are not affected by load mass or ruck type. Earlier research, however, suggests otherwise. Degeneration of shooting accuracy and vigor, as well as increase in fatigue and anger, was found to occur after prolonged marching (Knapik et al,

1991). Apparently more research is needed to better clarify the impact of load dynamics on soldiers' cognitive performance.

And finally, it should be noted that most soldiers reported no civilian backpacking experience prior to entering the military. The lack of prior experience suggests that knowledge about load carrying is obtained primarily through military training exercises and/or actual combat. The Army does not routinely offer special instruction or training in load carrying. The results of this survey suggest that those with more experience have acquired an intuitive knowledge about the biomechanics of load carrying as well as knowledge of the trade-offs between good biomechanics and the requirements of tactical combat. If the Army is to give the less experienced soldier some of the advantages of the more experienced soldier in this regard, it needs to give more formal instruction and realistic field training in effective techniques of combat load carrying. In the end, there is a performance benefit to be gained in combat operations in having soldiers who have good intuitive understanding of effective load carrying mechanics and technique.

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APPENDIX: LOAD SURVEY QUESTIONNAIRE

Name: _____ Date: _____

Instructions: *The following questionnaire seeks your thoughts and preferences about carrying loads on prolonged marches. The focus is NOT on combat operational factors but more on load carriage factors during extended movement. We are trying to describe soldier/marine preferences on load carriage based on their experience with loads. We appreciate the time you take on this questionnaire. Please read each question carefully.*

Section I: Background/Experience

1. **a.** Gender: Male : Female

   b. Age: ____ yrs

   c. Weight: ____ lbs

   d. Height: **____ ft ____ in.**

2. Years of military service: _____ yrs

3. Current MOS: _____ MOS title: _____

4. Have you had any special load carrying training or experiences? No : Yes

   If Yes, explain or describe (e.g., what, where, when):

5. Indicate type(s) of load carrying equipment you have used during your military service (check all that apply):

a. ___ Vietnam era packs and harnesses
b. ___ ALICE pack & frame.
c. ___ new MOLLE with quick-drop mechanism
d. ___ new MOLLE with attached belt
e. ___ H-harness/LBE
f. ___ Y-harness/LBE
g. ___ LBV (load bearing vest)
h. ___ Butt packs
i. ___ Detachable Assault or fighting pack
i. ___ Internal frame packs
x. ___ Other (list any you can recall):

6. Have you ever deployed into a combat zone with a fighting load? No : Yes

If Yes, describe, briefly:

7. Have you done much civilian back packing? No : Yes

If Yes, briefly describe types of activities and equipment used:

8. **Do you have a favorite or preferred type of load carrying system?** No : Yes

If Yes, describe:

Section II. Structured Questions on load carrying.

Answer the following questions based on your personal experiences or thoughts about load carrying in the military.

Considering deployment marches where enemy contact is NOT expected:

9. Is it advisable to place items so weight is distributed equally, to your front & back, as much as possible? (circle one)

a. Yes, it's advisable to distribute weight front & back.
b. No, disagree, there are better ways of doing it.
c. Can't say.

Comments or clarification:

10. Is it advisable to place items so weight is distributed equally, to your left & right, as much as possible? (circle one)

a. Yes, it's advisable to distribute weight left & right.
b. No, disagree, there are better ways of doing it.
c. Can't say.

Comments or clarification:

11. Is it advisable to place items so weight is distributed equally, top to bottom, of the pack, as much as possible? (circle one)

a. Yes, it's advisable to distribute weight equally top to bottom
b. No, disagree, there are better ways of doing it
c. Can't say.

Comments or clarification:

12. Is it advisable to pack heavy items close together, as much as possible? (circle one)

a. Yes, it's advisable to keep heavy items together
b. No, it's advisable to spread-out the heavy items
c. Can't say.

Comments or clarification:

13. From your experience, where is the best place to place heavy items? (circle one)

a. Inside ruck, close to the frame
b. On top of the ruck
c. Hanging off back of the ruck (farthest from body)
d. Underneath the ruck
e. Anywhere, it doesn't matter
f. Can't say

Comments or clarification:

14. How do you usually carry your rucksack? (circle one)

a. Tend to carry it primarily on the shoulders
b. Tend to use both shoulder straps and hip (LBE) belt
c. Don't have any special way of carrying loads

Comments or clarification:

15. With heavy loads, do you tend to keep straps, pouches and items attached loose or tight? (circle one)

a. Tend to keep things *loose.*
b. Tend to keep things *tight.*
c. I have *no preferred* way.

Comments or clarification:

16. Do you tend to maintain a *fixed arrangement or position* of your load system on your back/shoulders or do you try *to vary it* during a march? (circle one)

a. Tend to maintain a *fixed* arrangement/position throughout.
b. Tend to *vary* the arrangement/position from time to time.
c. I have *no preferred* way of doing it.

Comments or clarification:

17. If your movement was largely UP hill, how would you prefer the load be arranged?

a. Prefer most of the weight be *High* in the pack.
b. Prefer most of the weight be *Centered* in the pack.
c. Prefer most of the weight be *Low* in the pack.
d. It doesn't really matter to me.

Comments or clarification:

18. If your movement was largely DOWN hill, how would you prefer the load be arranged?

a. Prefer most of the weight be *High* in the pack.
b. Prefer most of the weight be *Centered* in the pack.
c. Prefer most of the weight be *Low* in the pack.
d. It doesn't really matter to me.

Comments or clarification:

19. Would you prefer a *long & narrow* ruck over a *short & wide* ruck for long marches? (circle one)

a. Yes, would prefer long & narrow rucksack
b. No, prefer short wide rucksack
c. I have no preference for either type

Comments or clarification:

20. When you get to soft or difficult ground (loose dirt, rocks, sand, snow), that can't be avoided, what would you prefer to do?

a. *Slow* down
b. Maintain *same rate* of movement
c. *Speed* up
d. Have *no preferred way* to move over difficult ground

Comments or clarification:

21. With heavy loads, do you prefer to keep your boots/footwear loose or tight? (circle one)

a. Prefer *loose* footwear
b. Prefer *tight* footwear
c. Have *no preference*

Comments or clarification:

22. With a heavy loads, do you prefer your boots to be heavy or light? (circle one)

a. Prefer *heavy* footwear
b. Prefer *light* footwear
c. Have *no preference*

Comments or clarification:

23. When faced with going <u>over a hill</u> with a heavy load, how would you prefer to proceed?

a. *Straight up* and over the hill
b. *Zig-zag up* and over the hill
c. Have *no preference*

Comments or clarification:

24. How important is it to you to have well broken-in footwear for prolonged marches?

a. Extremely important
b. Somewhat important
c. Slightly important
d. Not that important
e. Can't say

Comments or clarification:

25. How important is it to keep *most of the weight* near the center of your body and reduce the weight in the hands and on the legs and feet? (circle one)

a. Extremely important
b. Somewhat important
c. Slightly important
d. Not all that important
e. Can't say

Comments or clarification:

26. Do you prefer to shift the weight of the rucksack around during the march or maintain the load in the same position throughout? (circle one)

a. Prefer a *shift it around*
b. Prefer to *maintain the same position*
c. I have *no preference*, either way

Comments or clarification:

27. How important is it to train with the same weights and types of loads to be expected in combat? (circle one)

a. Extremely important
b. Somewhat important
c. Slightly important
d. Not all that important
e. Can't say

Comments or clarification:

28. If equipment will not fit inside ruck, where are you most likely to secure it? (circle one)

a. *Top* of the ruck
b. *Side* of the ruck
c. *Underneath* the ruck
d. *Back* of the ruck (farthest from body)
e. Can't say

Comments or clarification:

29. How much attention do you give to making your load comfortable?

a. Spend a *great deal of time* making load comfortable
b. Spend a *little bit of time* making load comfortable
c. *Don't spend much time* at all making load comfortable
d. Can't say

Comments or clarification:

30. How much *control* do you have on making your load comfortable?

a. Have a *great deal of control* in making load comfortable
b. Have a *little bit of control in* making load comfortable
c. *Don't have much control* at all in making load comfortable
d. Can't say

Comments or clarification:

31. Rate the relative <u>discomfort</u> you are likely to feel in various body locations after a prolonged march with loads:

	Discomfort					
	None	Slight	Some	Moderate	Great	Extreme
a. Neck:	0	1	2	3	4	5
b. Upper back	0	1	2	3	4	5
c. Mid back	0	1	2	3	4	5
d. Lower back	0	1	2	3	4	5
e. Shoulders	0	1	2	3	4	5
f. Arms	0	1	2	3	4	5
g. Hips	0	1	2	3	4	5
h. Legs	0	1	2	3	4	5
i. Ankles	0	1	2	3	4	5
j. Feet	0	1	2	3	4	5

Comments or clarification:

32. Rate the degree you feel the following symptoms or sensations after a prolonged march with loads:

	None	Slight	Some	Moderate	Great	Extreme
a. Muscle aches	0	1	2	3	4	5
b. Difficulty concentrating	0	1	2	3	4	5
c. Feel wobbly (less stable)	0	1	2	3	4	5
d. Walk differently	0	1	2	3	4	5
e. Posture changes (e.g., bent over)	0	1	2	3	4	5
f. Head drops slightly	0	1	2	3	4	5
g. Other: _____	0	1	2	3	4	5

Comments or clarification:

33. How much over all <u>discomfort</u> do you generally experience at the end of a prolonged march?

a. Have a *great deal of discomfort*
b. Have a *slight amount of discomfort*
b. Have a *little bit of discomfort*
c. *Don't have much, if any, discomfort*
d. Can't say

Comments or clarification:

Section III. Open ended Questions. (use other side of sheet if needed)

Answer the following questions based on your own experience or have heard from others. If you do not have an answer, observations or comments, indicate that by writing "do not know" or "no comment", or whatever phrase is appropriate.

34. What are the key advantages & disadvantages to external frame pack systems? (If you don't know or not sure, etc., write "don't know" or "not sure", etc.)

35. What are the key advantages & disadvantages to internal frame pack systems?
(If you don't know or not sure, etc., write "don't know" or "not sure", etc.)

36. What problems might be expected if weight in the rucksack load is packed too high?
(If you don't know or not sure, etc., write "don't know" or "not sure", etc.)

37. What problems might be expected if weight in the rucksack load is packed too low?
(If you don't know or not sure, etc., write "don't know" or "not sure", etc.)

38. What problems might be expected if the load is not well balanced ? (If you don't know or not sure, etc., write "don't know" or "not sure", etc.)

39. What problems might be expected if the load is loosely packed? (If you don't know or not sure, etc., write "don't know" or "not sure", etc.)

40. Do prolonged marches tend to impact your other duties as a soldier? No : Yes

If Yes, explain or give examples of the impact on tasks or duties.

END